WORKSHOP TO DEVELOP A GLOBAL INVENTORY OF BRAIN INITIATIVES

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SUMMARY REPORT – October 10th, 2018

DAY 1 - MONDAY, JULY 23, 2018

OVERVIEW

Presenters: Caroline Montojo, Director, Brain Initiatives and Science Program Officer, The Kavli Foundation; and **Melina Hale**, Professor of Organismal Biology and Anatomy, University of Chicago; Interim Director, Marine Biological Laboratory in Woods Hole. Hale co-leads the International Brain Initiative Working Group on the Global Inventory of Brain Initiatives with **Patrick Hof**, Professor of Neuroscience, Icahn School of Medicine at Mount Sinai. Hof was unable to attend the Inventory Workshop.

Presentation: The meeting began with an introduction to the International Brain Initiative (IBI) and an overview of its status. **Caroline Montojo** gave a history of the events—both scientific and high-level meetings—that have taken place since 2016, leading up to the IBI Global Inventory Workshop. Those included an initial gathering of approximately 60 scientists at John Hopkins University in April 2016 for the Global Brain Workshop, during which attendees brainstormed grand challenges in neuroscience that an IBI could aim to overcome. Subsequently, the Coordinating Global Brain Projects meeting at The Rockefeller University in September 2016, with approximately 400 attendees, provided a forum for learning about the various established and emerging national brain initiatives, and potential points of collaboration, cooperation and synergy between them. The same day, the IBI was the focus of a high-level discussion at the UN General Assembly in New York.

These meetings set the groundwork for a public declaration of intent to establish an IBI, which was announced in December 2017 at a meeting of some of the world's major brain research projects in Australia. The declaration reads, in part:

> "Researchers working on brain initiatives from around the world recognise that they are engaged in an effort so large and complex that even with the unprecedented efforts and resources from public and private enterprise, no single initiative will be able to tackle the challenge to better understand the brain."

Throughout 2018, the IBI Steering Committee members have been drafting an organizational vision and aims, and identifying priorities. They have also been attending scientific meetings to engage the brain research community.

Montojo itemized the IBI's immediate priorities, which are: a global Inventory; neuroethics; data sharing and standards; tool and technology dissemination; training and education; communication and outreach, and the IBI Coordinating Body framework. The Inventory, led by Melina Hale and Patrick Hof, is considered high-priority because it will help the global neuroscience community understand the research landscape and how the various national brain projects can work together to maximize the impact of new investments in neuroscience and accelerate progress in the field.

Next, **Melina Hale** gave a brief overview of the goals of the morning discussions, which were to consider the goals of an Inventory, what it would need to contain to meet those goals and how to measure its success. She called on the Workshop participants to think aspirationally about what global neuroscience could look like 10 years from now.

DISCUSSION 1: THE INTERNATIONAL BRAIN INITIATIVE INVENTORY IDEA

Moderator: Melina Hale
The goal of this discussion was to brainstorm what a global inventory of brain initiatives should achieve for its stakeholders. The intended outcome was a set of core functions the Inventory could perform.

IBI Inventory: A Vision

During this initial, wide-ranging discussion about what a global inventory of brain initiatives should achieve, the conversation quickly turned to vision and scope. Would an Inventory take stock of active research projects around the globe, including who and what has been funded

by the national brain initiatives? Or, would it a play a broader, programmatic role in global neuroscience, for example, by shaping global brain research priorities and funding? A third possibility the group discussed is that an Inventory would do both: serve as an aggregator of global brain research projects; and, provide a mechanism for building communities around certain research questions, instruments or datasets, identifying research gaps, inequities and opportunities, informing decisions and even measuring the success of programs initiated by the IBI. Indeed, the idea of an Inventory as a galvanizing force for building community, rather than merely a data repository or aggregator, had significant traction with the participants.

One participant envisioned the Inventory becoming the "go-to" database for brain researchers—a comprehensive resource that scientists would consult at the outset of a project, in much the way they consult would consult Google Scholar or PubMed today. Investigators would use it to gather relevant background information, e.g., who is already working on a particular problem and how they are approaching it. Such a resource would be consistent with the International Brain Initiative's aims to leverage global resources to enable better, faster and more efficient neuroscience. Specifically, it would help solve the information filtering problem in science, enabling new research projects to get off the ground more quickly and avoiding unnecessary duplication of research. Another participant suggested that for Inventory to be unique from other scholarly search engines and databases, and of maximal use to the community, it should contain information from the point of funding, prior to archiving and certainly prior to publication.

In addition to finding data, the participants envisioned using the Inventory to find collaborators or partners, in academia but also in industry, as well as tools, ranging from instruments to reagents to algorithms.

They also imagined the Inventory as a hub for training, geared at researchers at all career stages, from principal investigators to students, perhaps through online modules. Participants emphasized the need to reach trainees—the next-generation of neuroscientists—and provide them with the opportunity to share and learn from one another.

Lastly, it was pointed out that the Inventory is a priority for the IBI because it could be used to guide the IBI's strategic decision making. Some participants envisioned doing a network analysis of the Inventory's dataset, or knowledge graph, to develop a picture of the global neuroscience landscape. This could allow the IBI to identify research gaps or funding inequities, and to measure the impact of new programs or initiatives over time. Relatedly, the IBI could be used to identify clusters of scientist show can be brought together in countries

where brain initiatives do not exist and help to raise their profile with government and potential funders.

Micro-, Meso-, or Macroscale

This discussion prompted the question, what scale of information would the Inventory try to capture or aggregate? For example, a "microscale" Inventory could contain information at the level of individual investigators or laboratories, including who has been funded, where and for what. A "mesoscale" Inventory could focus instead on research at the level of university departments or institutes. At the "macroscale," an Inventory would capture the research being broadly funded by the national brain initiatives such as the EU Human Brain Project and the U.S. BRAIN Initiative. Most participants agreed that a searchable, microscale Inventory of internationally funded brain research projects would be a unique and highly valuable resource, but also the most challenging to build.

IBI Inventory and Data

Throughout the discussion, participants contributed many other ideas about what the Inventory could achieve. In addition to the core functions of connecting national brain initiatives and leveraging resources globally to promote better, faster neuroscience, the role of an Inventory in data storage, standardization and sharing was as a key discussion topic. Participants generally agreed that it was beyond the scope of an Inventory to solve the data-sharing problem in neuroscience. However, many felt that having the ability to use the Inventory to find — and, ideally, access — neuroscience datasets was essential. Some participants suggested the Inventory could play a role in establishing best practices or standards for neurodata, including data collection, analysis and sharing, in much the way the Human Genome Project has done for genomic data.

IBI Inventory: Challenges

Woven into the morning discussion were many comments and ideas about how to implement an Inventory, including the challenges associated with doing so. This was also the focus of subsequent discussions, however, some of the participants' initial thoughts on implementation are summarized here.

One of the biggest challenges will be sustainability. It was pointed out that neuroscience already has a resource called the Neuroscience Information Framework (NIF)— self-described as "the largest searchable collection of neuroscience data, the largest catalog of biomedical resources, and the largest ontology for neuroscience on the web." Yet, NIF was unknown to

many of the participants and, a quick search of its catalog yielded many links that were dead, outdated or private. This prompted the participants to ask: How would a global inventory of brain initiatives differ from NIF and bring added value to the community? What could the IBI learn from NIF? And, how should an Inventory be sustained?

In relation to sustainability, the participants weighed the merits of a top-down (IBI-driven) versus a bottom-up (community-driven) approach to collecting and maintaining the Inventory's data, and the role that partnerships could play in meeting some of the Inventory's goals. As an example of a bottom-up approach, some participants suggested crowdsourcing could be an effective way to create a successful Inventory; users could be incentivized to contribute data to the Inventory in much the same that Google for Business attracts small business owners. In return for providing Google with information about their business, such as hours of operation, location, and more, the business is indexed in Google's knowledge graph, where it can be easily discovered by potential customers using Google's search engine. To build Google for Business, the company established a structure and schema, or way of describing data, that business owners use to input their data. It might be possible to develop a similar structure and schema for scientists who want to contribute to the Inventory. Yet the question remained, what incentives would the Inventory provide to scientists? Other participants felt that the only way to create a comprehensive Inventory would be to commit significant resources to building it using a top-down approach, to test how the Inventory works, and to iterate based on that.

Participants suggested several organizations, enterprises or initiatives that could serve as potential partners or resources for a global inventory, including: NIF, International Neuroinformatics Coordinating Facility (INCF), the International Brain Research Organization (IBRO), which maintain data on neuroscience research in countries around the world, ORCID, scientific publishers, brain banks and even Google. (See the **Appendix** for a complete list of potential partners or resources mentioned during the Workshop.)

Key discussion points and takeaways

The Inventory should:

- Aggregate data from national brain initiatives, from the point of funding
- Build community, for example by helping researchers find collaborators, data, technologies, software, etc.
- Inform the IBI's decisions
- Serve as a global training hub

- Build on existing databases, infrastructures and initiatives rather than reinvent them
- Help researchers find and/or access relevant datasets rather than host datasets
- Help establish and promote standards and best practices in neuroscience research, including data sharing

Outstanding questions include:

- The scale of information contained in the Inventory: micro-, meso-, or macroscale
- How to build the Inventory: top-down versus bottom-up
- How to sustain the Inventory

DISCUSSION 2: DEVELOPING A SUCCESSFUL INVENTORY

Moderator: Melina Hale

The goal of this discussion was to identify the specific information and materials that should be included in a global inventory of brain initiatives. The intended outcome was a list of requirements to meet the set of functions identified in the discussion.

This discussion aimed to bring the earlier "blue sky" thinking down to earth, and focused on developing a list of functions and related requirements for the global inventory of initiatives.

IBI Inventory: Refining the vision

Participants continued to refine their vision of an Inventory. At its most basic, they envisioned it as a global version of NIH RePORTER, an electronic tool that allows users to search a repository of research projects funded by the US National Institutes of Health (NIH). In addition to project descriptions, RePORTER contains publications and patents stemming from the projects. As an international repository, the Inventory would bring together all the research projects funded by the national brain initiatives into a searchable database. At the very least, it would contain information on the funding agency, researcher profiles (including principal investigators, along with their institutions and contact information), project descriptions and related publications. The Inventory could begin by pooling data from the existing brain initiatives and expand as more national initiatives are launched.

One of the participants noted that there is a "compelling completeness" to this vision, and it would offer the neuroscience community something that does not exist. Furthermore, he noted there is already an incentive to keep each of the underlying information sources, the national brain initiatives, funded and maintained.

A more expansive form of the Inventory would also contain information on: all scientists involved in a project; related datasets; research tools, including algorithms (software) and instrumentation (hardware). Another addition could be a visualization layer, or a network mapping function, that would allow user to understand the connections between different research groups, countries or other data types, and to track changes in the data over time.

An Inventory could also serve as a centralized resource for funding opportunities offered by the brain initiatives.

Participants pointed out that there are several existing resources that include some or all of these elements and could form the basis of an Inventory. For example, the Neuroscience Information Framework's standard ontology, a way of organizing information in a complex database, is a collection of thousands of terms, or concepts, to describe neuroscience data and resources. For example, the ontology's categories include organisms, cell, molecule, neurological disorder and more. Using an existing ontology, such as NIF's, would expedite the development of an Inventory and help ensure that it can integrate data from multiple sources.

Another participant suggested using ORCID, which assigns a persistent digital identifier to researchers that makes it easier to link them to their grants, publications, data sets and other professional information. Other open science projects are pioneering the use of persistent identifiers, such as DOI (Digital Object Identifier), to ensure data producers receive credit for their work. These could be integrated into a global inventory and help change the culture around data sharing in neuroscience.

In general, the participants recognized the need to build on existing resources and employ best practices in data science to maximize the Inventory's value. For example, an Inventory could take advantage of recent progress in semantic search and recommendation engines to deliver more relevant search results to its users.

The participants also suggested that the information contained in an Inventory should be translatable into multiple languages, and that the system itself should be adaptable, in order to accommodate new concepts in neuroscience, and interoperable, to ensure information from other sources can be integrated and exchanged.

Data revisited

A detailed discussion about data followed. It was again suggested that storing and making neuroscience data sets available to users is beyond the scope of an Inventory. However, some participants stressed that an Inventory could help users to discover what data are available, much as platforms like the Global Alliance on Alzheimer's Interactive Network, or GAAIN, do. Specifically, GAAIN links scientists at Alzheimer's disease study centers around the world with shared data sets and analysis tools to accelerate research. One participant stressed that even pointing people to shared datasets is a complex task because there are barriers to access that arise because of differences among countries in research ethics and regulation, and data governance.

An Inventory could also help promote global data standards and best practices for neuroscience such as the FAIR principles, a set of guidelines to ensure that data are Findable, Accessible, Interoperable and Reproducible. This point prompted the question of whether an Inventory, or the International Brain Initiative more broadly, should develop a set of common principles, such as data sharing and inclusivity, that participating nations would need to adhere to.

Finally, another participant suggested that a global inventory could also help promote the development of data sets that would be useful to the global neuroscience such as psychology and invertebrate biology.

Users and Use Cases

Next, participants discussed who the Inventory's users will be and what types of questions the Inventory should be able to answer. What would success look like to different users? Answering these questions will help establish specific use cases that will inform the Inventory's priorities and requirements. The participants suggested building the Inventory to address a few crucial use cases, and then growing it in phases. Different phases could potentially be supported by different grants from funding agencies, in 3-year cycles.

Implementation

The discussion eventually turned toward implementation. How could an Inventory be built to meet the needs of its users, such as those identified above? Where has a version of this problem already been addressed? Participants reiterated that Google for Business might be a useful model. Its massive database is built using "Google structured data," an open data standard that describes local businesses. Could an Inventory be built in a similar way? Is there an off-the-shelf solution that would satisfy some or all these requirements? What incentives would attract people to input their data and use it?

Participants considered two ways of developing the data structures and schemas that would be necessary to support an Inventory: 1) The IBI Working Group could lead the global search for an existing structure and schema that could be adapted, and work with its developer (a quick web search yielded ResearchGraph.org and Interfolio, a private company focused on managing faculty data) or 2) The Working Group could build a request for applications, and favor developers with an established product.

Further discussion about incentives led to the suggestion that to establish a successful Inventory, it would need to "pull" data out of people initially. Once the value of the Inventory was established, people would start "pushing" their data to the system, but it will take time to get to that point. The Inventory could create incentives, such as training opportunities, over time. Tools associated with the Inventory, such as analysis tools, could also help popularize it and become standard in neuroscience, in much the same way the GenBank's alignment tools for DNA sequences have become standard in genomics.

One participant suggested the Inventory could develop and share templates or boilerplate agreements for collaboration, data sharing, consent and licensing, animal studies procedures, akin to what Creative Commons does for creative content. These could attract and incentivize users and foster more openness and alignment with the IBI's goals to foster a more cooperation and collaboration among brain initiatives.

Funding

Participants raised the issue of funding and how to sustain an Inventory beyond a given funding cycle. One suggestion was to think of the Inventory as a data integration problem, in which data from different sources, such as the Human Brain Project and the National Institute of Health, are being linked together. The Inventory could grow link by link, or node by node,

and those different phases could be funded independently. Similarly, an Inventory could start by focusing on linking resources at the "mesoscale" — at universities and other Institutions involved in the brain initiatives, then grow up (to the "macroscale") and down (to the "microscale"). Funds could be directed toward connecting those levels.

One of the Workshop observers echoed this idea by suggesting participants think about discrete projects that could be implemented over 3-year spans. There are funds available to leverage the investments the funding agencies have already made in brain research and data science, such as the NSF's Harnessing Data Revolution program. International efforts are also highly valued by funders, and, in general, there is widespread interest and support for neuroscience.

Key discussion points and takeaways:

- At a minimum, the Inventory should resemble a global version of NIH RePORTER, a searchable repository of funded research projects
- Additional features could include:
    - network mapping function / knowledge graph / relational database
    - semantic search / recommendation engines
    - multiple languages
    - funding opportunities
- The Inventory should also be:
    - Built to be adaptable, scalable, interoperable
    - Promote FAIR data principles
    - Establish a set of common principles, in addition to those related to data sharing, such as inclusivity
    - Offer incentives to users in the neuroscience community, such as analysis tools
- To implement an Inventory, the IBI Working Group should:
    - Establish use cases
    - Survey existing resources and adopt best practices, such as the Neuroscience Information Framework (NIF) and its standard ontology, and ORCID
    - Evaluate funding opportunities
- There is funding for brain research and funding agencies want to leverage their investments

BREAKOUT SESSIONS TO DEVELOP SPECIFIC FEATURES OF AN INVENTORY

Breakout Group Leaders: Amy Bernard, Rui Costa, Sean Hill and Sandhya Koushika

The goal of the breakout sessions was to take a deep dive into the following questions, developed in response to the morning discussions:

- *Group 1: What is the added value of an Inventory? What are the incentives that would motivate different stakeholders to use and contribute to the Inventory?*
- *Group 2: What are the measures of success of an Inventory (ranked and prioritized; short-, mid- and long-term)?*
- *Group 3: What existing efforts could be leveraged (best practices, skills, global accessibility, or tools and technology)?*
- *Group 4: What is the minimum information that should be included in the Inventory (ranked; guiding principles)?*

The following is a summary of the breakout sessions.

GROUP 1: STAKEHOLDERS AND INCENTIVES

Facilitator: Sean Hill

This breakout group discussed the added value of an Inventory and the incentives that would motivate different stakeholders to get involved. Potential stakeholders and incentives are summarized below, in no particular order. The summary includes additional suggestions that came from the Workshop participants.

Researchers (primarily academic neuroscientists)

- Increase visibility (of individuals and their research)
- Increase awareness of neuroscientists as a group (lobby), which in some countries could help establish brain research as a national priority
- Efficiently survey research under way around the world (one-stop resource)
- Identify opportunities such as resources (funding opportunities to software), collaborators. If the Inventory is implemented as a knowledge graph, neuroscientists could receive recommendations on, for example, related data sets.
- Get an integrated view of what's been funded; this could be used to find and fill gaps in brain research

- Demonstrate research impact or productivity using, for example, an Inventory-based metric (index, such as SemanticScholar's)
- Access and disseminate data and technologies
- Discover job posts, networking opportunities, funding opportunities

Trainees, students, post-docs (next generation)

In addition to the bullet points listed above for individual researchers, an Inventory would help trainees, students and post-docs:

- Access training
- Find collaborators and expertise
- Identifying opportunities to conduct novel research or make a novel contribution to the field

Other researchers (social scientists / economists)

- Conduct research on the science of science (e.g. evaluation of global brain initiatives; study of the effectiveness of large-scale team projects)

Institutions and their staff (universities, institutes, hospitals)

- Provide institutional visibility. Note: KAUST actually requires faculty to register for ORCIDs, which raised the question, would an institution mandate registration with the IBI in order to ensure representation in the IBI?
- Advertise funding opportunities to researchers, students, staff
- Help patients finding doctors or researchers with specialized expertise
- Facilitate the development of courses or meeting, again by helping organizers find individuals with specific expertise

Countries and/or national neuroscience organizations

- Provide high-level view of who is doing what, where
- Measure the impact of national cohort of scientists
- Track international collaborations

National Brain Initiatives

- Raise visibility
- Attract talent and foster engagement with brain initiative
- Showcase scale and diversity of research projects
- Track and demonstrate ROI

- Demonstrate uniqueness or complementary among global brain projects
- Identify and fill gaps in global neuroscience research
- Establish linkages between projects and solidify collaborations between initiatives by, for example, identifying opportunities for travel grants
- Shift the culture of global neuroscience by establishing common standards and best practices

International Brain Initiative

- Elevate neuroscience to a big science approach
- Globalize or catalyze the creation of very large-scale projects

National research funding agencies

- Attract better proposals from scientists worldwide, by using an Inventory to design and market funding RFAs
- Identify a specific niche in neuroscience that complement other efforts or fills gaps

Industry (neurotechnology, device manufacturers, publishers, IT, pharma, software developers)

- Access a specific market of researchers with their products
- Identify market needs that could be fulfilled, such as hot topics, trends, equipment
- Find reviewers, employees, collaborators
- Develop public-private partnerships
- Find experts or consultants

Patients or patient advocacy groups

- Find experts
- Find patients
- Find researchers to fund (targeted funding)
- Connect families

Private philanthropies

- Find experts
- Find researchers to fund

Other potential stakeholders:
Entrepreneurs and investors
Educators
Media
General public

Hill noted that within the breakout group, there was a lot more interest in the social or community-related benefits of an Inventory, rather than in finding or accessing data, though this could change as data sharing becomes more common. The group also emphasized the importance of designing an Inventory with the next-generation of neuroscientists in mind, not just in terms of their needs as trainees but also how they use digital technologies and what they expect those technologies to deliver. They also discussed the high value of building an independent, non-commercial, collaborative research platform that could attract the participation of stakeholders globally.

Lastly, in relation to incentives, the group briefly discussed incentive structures that could attract participants to the Inventory and reward users in various ways. Ideas included an X Prize for neuroscience, IBI Fellows program, badges or leaderboards to recognize users and contributors, e.g., top data contributors, awards and various elements of social networks, such as private groups or Slack-like collaborative tools.

GROUP 2: MEASURES OF SUCCESS
Facilitator: Amy Bernard

Bernard presented the results of a breakout group discussion on measures of success. They asked themselves: What kind of information, housed in an Inventory, could change my life? And they considered how an Inventory could drive change both for the field of neuroscience and for neuroscientists, and how to measure that objectively. The group focused less on developing a list of concrete metrics and more on charting a path toward that list, including the need to embed information gathering and analysis into the Inventory.

The group's key recommendations at one year, three years and five years are summarized below. Figure 1 captures the breakout group's notes.

Recommendations for Year One

- Define the Inventory's audience by developing personas for potential users.
- Establish a small (~30 person) group of beta participants who represent the Inventory's intended audiences. They would serve as data providers and users, and in addition to testing the tool itself, influence how the Inventory is built and utilized.
- Establish a basic web portal, including a "charter" that describes what the website is, along with guidelines for users.
- Set benchmarks or target metrics for who will use the site and from where
- Gather baseline data. Measure usage by site metrics and an international survey.

Recommendations for Year Three

- Look at other models of team science, such as the National Cancer Institute and think about how the Inventory can foster collaborations.
- Define variable thresholds or levels of contribution and accessibility.
- Propose a model for data collection that would facilitate social science research about the Inventory itself, as a global, collaborative community.
- Survey the community again.
- Consider whether the Inventory experience could be customized to specific users.

Recommendations for Year Five

- Establish and ID the content that is coming through all the brain initiatives that would facilitate analysis and attribution.
- Measure trends and outcomes for neuroscience and neuroscientists.

Following Bernard's presentation, the discussion focused on the need to establish specific metrics that distinguish the impact of the Inventory from the impact of brain initiatives. Participants commented that neuroscience is inherently interdisciplinary and wondered where the measures of success should relate specifically to building community around that interdisciplinarity. Another wonder was whether diversity should be considered a measure of success. For example, the Inventory could establish specific benchmarks for site usage from different parts of the world. The breakout group also thought about training as a metric that could be used to measure success.

Finally, the group discussed cost and the need for a long-term commitment to building and maintaining an Inventory. The resources could be tied to some of the steps the group identified, such as surveying users.

Figure 1. Notes on measures of success

Year 1:
Establish criteria for trend analysis (surveys) - baseline for trend analysis

- Beta community of participants
- Instantiating a 'web portal'
- Early adoption: usage by site metrics and survey internationally; begin by setting a framework of solicit feedback to gather baseline data.
- Define audience: Develop personas so that we could use those people to shape the site
- Determine awareness of IBI; via 'Check a box" for other funding agencies
- Establish framework for scalability (model: Kavli's search for existing funding opportunities)

Year 3:

- Look at other models of team science - NCI model of team science as a framework for creating a 'collaborative contract'; pair with a mechanism to evaluate changing perspectives over time
- Define variable thresholds / levels for contribution, accessibility
- Propose model for data collection that would facilitate analysis of the social science of the site itself
- Leverage recruitment; like SfN jobs
- Solicit structure impact evaluation: survey participants
- 1.0 version of a 360-degree feedback tool
- Analysis of the social science of the site itself. create a way to do that. work with social scientists…
- community feedback (again)
- Customization of experience / faceting experience based on self-identification - Choose your adventure customization. content, schema early markers

Year 5:

- Some sort of ID of the content or the research or the science that is coming through all of the brain initiatives. Analysis.
- Objective evidence we can use related to neuroscience. What is happening to improve neuroscience?? Harder to figure out how to measure. Not to diminish the training / community aspects.

iNIF - "information resource" - how do we leverage and learn from what came before. apply what worked and learn from what did not. investigate NIF. Specifically related to info resources.

Other points:
- Attribution - RR IDS (Research resource IDs - barcoding way to identify and reference resources)
- Track citations

What is our impact? E.g., "Changed my life"
Objective evidence.
- for neuroscience (topic)
- for neuroscientists (people)
- for other / global, i.e., WEF
Define pre- and post-benchmarks and evaluation

GROUP 3: LEVERAGING EXISTING EFFORTS
Facilitator: Sandhya Koushika

Breakout group 3 discussed how to leverage existing efforts to create a global inventory of brain initiatives. They brainstormed ideas for best practices, as well as the existing skills, tool and technologies that could be incorporated. Finally, they considered how to ensure the Inventory is globally accessible. The group's key points are summarized in Figure 2.

The group proposed building the Inventory from existing databases, when possible, by extracting information about funded projects and their investigators. The Inventory would bring those data together into a relational database. A second phase would encourage investigators who are not represented in those databases but who are part of a brain initiative-funded project, to input their data. This phase of development would be curated to maintain quality.

Skills, tools and technology
The group listed a handful of existing initiatives, including the Neuroinformatics Information Framework (NIF), that could serve as a resource to help the IBI determine opportunities and challenges related to building a global Inventory. For example, what information sources already exists and how readily can they be integrated? Who could assist in building the Inventory? And, critically, what can the IBI learn from others about sustaining an Inventory?

Building an Inventory that captures information about tools and technologies will be particularly challenging because it is not widely available. The group suggested taking advantage of text-mining tools to extract that information from grant applications and reports and link it to individual investigators.

Best practices
The group suggested the Inventory could be instrumental in establishing and perpetuating best practices and/or minimum common standards—for data standardization as well as consent, licensing, experimental protocols for animal research and more. They suggested the Inventory could encourage scientists in the same field to come together and establish best practice guidelines and/or minimum common standards for data collection that would be published on the Inventory website and serve as a framework for training. The IBI could also work with experts, such as ethicists and lawyers, to establish common frameworks for things like consent, licensing, data sharing, MOUs, etc., which often serve as barriers to progress. The goal would be to generate a set of agreements or guidelines that would ensure investigators

could share data or other tools from country to country. These documents could be made publicly available and form the basis for agreements between other countries, helping to overcome accessibility issues.

Training

The group felt that training should be a priority, from the earliest stages of the Inventory. They brainstormed several training models, including training the trainer, establishing IBI Fellows, and adapting software carpentry, an established way of teaching basic skills in research computing.

Figure 2. Existing efforts to leverage

Best practices? Skills, tools and technology? Global accessibility?

1. Connect researchers and funded projects by extracting information from funding sources (public sources)
2. Encourage people to self-register a project (use ORCID)—build a national infrastructure (curated)
3. Learn from existing databases, e.g., NIF, Cordis, Loni, NIMH-data archive, Force11, GoFair (Some of these people will have skill set and knowledge to contribute)
4. Use automation / text mining to link tools & technology to people
5. Encourage each field to establish best practices—Bids neuroimaging, MINDS etc—and publish online; provide basic training.
6. Establish best practices for simplification for individual investigator & common framework for consent, licensing, data sharing, MOU—across countries with brain projects. Make publicly available to be used by others.
7. Training—building the next generation. Get off the ground. Train the trainer, software carpentry as a model—computational skills, mini neurosc. Feedback from outside your ecosystem. Enter people trained into the database. IBI fellow.

GROUP 4: ELEMENTS OF AN INVENTORY

Facilitator: Rui Costa

Table 1 summarizes the minimum set of data elements the group felt should be included in the Inventory, noting that not all subcategories would be required. They are divided into six categories, with the first five (Project/Initiative, Organization, People, Resources and Opportunities) considered essential. The sixth category, Outreach and Events, is optional or could be incorporated into the other sections. The group also suggested including links for

"Feedback" and "Wanted," meaning elements that the community would like to see added in the future.

The key use-cases that emerged during the breakout group's discussion were: 1) I want to know what projects or initiatives are already out there, 2) I want to find people with a particular expertise, or what certain people are working on; and, 3) I would like to find a piece of software or another resource.

Table 1 does not capture the connections between categories and elements but the Inventory would be to link the data together into a searchable database. This is what would set the Inventory apart from existing resources such as ResearchGate and other scientific social networks.

The discussion raised the question of whether "Opportunities" was a separate category or part of Projects, Organizations and People. The breakout group members did not discuss how to structure the Inventory but wanted to ensure elements such as job opportunities, funding opportunities, collaborations, etc., are captured in the Inventory. They viewed this section as something that would likely be implemented after Project, Organizations and People.

The group also mentioned that the Inventory data could combined to create an "altmetric" for evaluating and recognizing researchers. For example, there are few incentives for researchers to share data. An altmetric based on the Inventory could provide a way to recognize those who share high-value datasets.

Another discussion point was whether the Inventory would include active and inactive projects and what would happen to complete projects. Participants felt it would be beneficial to include both, in part because it would help funders (and others) track progress over time.

TABLE 1: Minimum data elements of a global inventory of brain initiatives

Project / Initiative	Organization	People
Mission/Objectives Project contact info Who/Researchers • Collaboration type • Role Structure / Organization Funding level Publications Timeline Subprojects Ethics / Code of conduct Products / Outcomes	Type Role Links to projects, people, resources	Contact info / ID (ORCID) Expertise Network / Collaboration • Internal • External
Resources	**Opportunities**	**Outreach & Events**

Purpose
 	
Type
• Software
• Hardware / Equipment
• Data
• Standard protocols
• Documents
  ○ Specifications
  ○ Publications
	Funding opportunities
	• Level
	• Agency
	• Timeline
	
	Jobs
	
	Collaboration / Contribution
	
	Training
	
	Participation
		Type
		• Training
		• Schools
		• Etc.

- Biological resources
- Wetware reagents
- Facilities
- Etc.

Metadata

- Standards
- Maturity level
- Usage guidelines
- Access rules
- Ethics

DAY 2 - TUESDAY, JULY 24

OVERVIEW & REVIEW OF DAY 1

The second day of the Workshop opened with a brief presentation by **Caroline Montojo** of The Kavli Foundation about the International Brain Initiative (IBI), including a draft of its vision and aspirational goals, an overview of its governance, and a summary of recent milestones and future events.

Following the IBI overview, **Melina Hale**, co-host of the Workshop, asked the participants for additional thoughts and ideas about the previous day's discussion. This prompted a brainstorming session of alternatives to the term "inventory," which some participants felt did not capture the dynamism and potential of the resource being discussed, or the community aspect of it. Others pointed out that, by definition, "inventory" means a complete list, which may set unrealistic expectations with potential users.

Others defended the name, asserting that it is clear and widely understood. Another suggestion was to use a catchy name or acronym, followed by an explanatory tagline.
One way to finalizing a name might be to focus on function instead of structure; another might be to ask: What distinguishes the "Inventory" from other commonly used tools such as Google and Wikipedia?

Whichever name is chosen, it should be a word that will resonate globally.

Short list of alternatives to the term "inventory":

- Navigator
- Repertoire
- Network
- Hub
- Census or Live Census
- Catalyst
- Engine
- Gateway, e.g., International Brain Initiative Gateway (iBIG)
- Resource
- Brainquest
- Brain map[1]

DISCUSSION 3: CONCERNS AND RISKS

Moderator: Melina Hale

The purpose of this discussion was to brainstorm outstanding issues related to an Inventory, as well as potential risks and how they could be managed or avoided. The outcome was a list of potential issues and solutions.

What follows is a summary of potential risks associated with the development of a global inventory and how to avoid or mitigate them.

1. **Risk**: Lack of a concrete or focused vision for an Inventory.
   Solution: Start with the problem the Inventory should solve or a need it should fulfill, and establish appropriate measures of success. Consider what similar efforts are trying to achieve and why they are or are not working. To borrow from the private sector, ask: What is the Inventory's value proposition?

2. **Risk:** Inventory is redundant.

[1] Note: Alternative names need to be vetted to avoid existing, active websites (e.g., www.brain-map.org and www.brainmap.org already exist).

Solution: Avoid replicating what others are doing. Develop a broad set of use cases involving a range of stakeholders, identify those that are currently unfulfilled by other tools, and ensure an Inventory will meet those needs. To borrow again from the private sector, ask: What market niche will the Inventory fulfill and how will it distinguish itself from its competitors?

3. **Risk:** Poor buy-in from stakeholders. This buy-in could take the form of funding, technical expertise, data or other in-kind contributions.
   Solution: Continue engaging stakeholders from the various national brain initiatives to ensure an Inventory will meet their needs. Conduct a survey with the brain initiatives about what kind of data they collect, how it is organized, what resources they could contribute, and more. Use this to build awareness and get their buy-in, especially at the leadership level.

4. **Risk:** Inventory is unsustainable and becomes outdated.
   Solution: Limit the scope of the Inventory initially. Focus on seeding the database from the outset and updating it regularly. Automate data collection as much as possible rather than relying on the community to input or update data. Structure the database from the outset to take advantage of researchers' workflow and existing data sources. Ensure the database is robust, so it can be adapted and upgraded over time. Use the best tools available, for example, open-source solutions instead of proprietary solutions, which may be harder to adapt over time as the user community's needs evolve. (Commons themes: scalability, adaptability, interoperability.)

5. **Risk:** Inventory is underutilized.
   Solution: Focus on clearly communicating what the Inventory is and what it brings to the global neuroscience community. Set the users' expectations up front and keep it simple. Build on early success to grow the Inventory and its community of users.

6. **Risk:** Inventory does not serve the global neuroscience community.
   Solution: Consider language, translation and accessibility when developing use cases and requirements. Involve stakeholders and partners from around the world at all stages of planning and implementation, including its governance and the support structures.

PANEL DISCUSSION: ASK THE "IMPLEMENTERS"

Moderator: Rui Costa

Panelists:

- **Amy Bernard**, Product Architect at the Allen Institute for Brain Science, where she serves as part of the leadership team providing strategic design and direction for the Institute's web products;
- **Jan Bjaalie**, Professor at the University of Oslo and leader of the EU Human Brain Project Neuroinformatics Platform; and
- **Sean Hill**, Director of the Krembil Centre for Neuroinformatics at The Center for Addiction and Mental Health in Toronto, Canada, and former Co-Director of Blue Brain and leader of its neuroinformatics division.

The goal of this panel discussion was to learn from and ask questions of three workshop participants who have first-hand experience implementing large-scale neuroscience projects.

The Workshop finished with a panel discussion about implementation of computing platforms for neuroscience projects, such as the Allen Mouse Brain Atlas, the Human Brain Project and the Blue Brain Project, all of which involve large-scale data infrastructure and multiple partnerships. It was moderated by **Rui Costa**, who led the discussion with a series of questions before turning to the participants for additional questions and comments.

Next steps

Costa began by asking the panelists to recommend next steps. They suggested the following: Develop a focused vision of the Inventory and representative use cases; establish a clear set of priorities based on that vision; and match those with specific outcomes. The group should also engage the Inventory's main stakeholders, including scientists from all career stages and IBI member nations, and gather focused feedback on their vision.

Specifically, they commended their fellow participants on the progress they had already made, then recommended continuing to build and refine a list of specific functions and system requirements, and to match those with specific outcomes. They suggested gathering input from additional stakeholders as soon as possible and providing those stakeholders with a defined period of time to provide focused feedback. That feedback could include incentives for participation, specific user requirements, technical expertise, best practices, and even data sources (along with a commitment to sustaining them for the lifespan of an Inventory). The panelists stressed that at the heart of the Inventory, as conceived over the course of the

Workshop, is a data integration problem. Success at creating a valuable resource for the global community of neuroscientists ultimately hinges on winning the buy-in and participation of the different stakeholders.

A “white paper” could be used to communicate the vision of the Inventory to the community and seek its input. One panelist underscored the importance of publishing IBI-related content in open-access journals, both for practical reasons and in the spirit of fostering open and global science. A participant urged the group to think about more creative approaches to engaging the international neuroscience community during the various stages of developing an Inventory.

Costa finished by summarizing the comments and advice from the three panelists, who agreed that the Workshop had made significant progress in identifying what an Inventory should be and what it should not, as well as developing a list of scientific requirements, measures of success, best practices and stakeholder incentives. For example, the focus of the Inventory is networking scientists and not the storage, standardization and sharing of data. The Inventory should also build on existing efforts rather than reinvent them, and learn from their strengths and weaknesses.

Lessons learned

Next, the panelists took questions from the Workshop participants, starting with what lessons they’ve learned that can be applied to the Inventory. Responses included: be clear on outcomes and keep them few; do not be afraid to start small and iterate; it’s better not to over promise but rather under promise and over deliver; and, avoid getting tied up making decisions by asking yourself, Will I be much more informed in two weeks or two months from now?

Training

The panel discussion closed with a question about how training is integrated into projects such as the Human Brain Project and the Allen Institute’s web products, and what the IBI could offer with respect to training. HBP runs in-person training workshops and MOOCs (massive open online courses), and partners with INCF to create online training videos. The Allen Institute has focused less on training and more on generating data, creating standards and building tools to make those data accessible and useful to the neuroscience community. However, the Institute receives a lot requests regarding training and is considering how to better support scientists interested in using its tools. Panelists advised thinking about how to build in training early and how to support it. For example, the Inventory could offer online

training and develop training modules as part of the IBRO summer schools, which are offered around the world in partnership with UNESCO. Other ideas including naming "IBI fellows" and using the implementation of the Inventory platform itself as a training opportunity for students and postdocs in the field of neuroinformatics.

Key discussion points and takeaways

Next steps in developing the Inventory:

- Establish a clear vision, and priorities based on that vision
- Develop use cases, and a list of scientific requirements based on those use cases
- Establish well-defined outcomes (measures of success)
- Engage with and solicit feedback from stakeholders
- Publish a white paper to share vision and engage stakeholders
- Integrate training into the Inventory from the outset

Additional recommendations:

- Adhere to open science principles including publishing in open access journals
- Start small and iterate, building on initial success
- Focus on a small group of major stakeholders

CLOSING DISCUSSION: USE-CASES AND POST-MEETING SURVEY

Moderator: Melina Hale

For the final session of the workshop, all participants were given the option to provide specific Inventory use-cases. The purpose of this discussion was to get a comprehensive list of use-cases representative of the individuals in the room. The list of use-cases will be transformed into a survey to assist in creating a priority list of Inventory uses from the various stakeholder groups.

What follows is a summary of the use-cases described by participants, organized into categories which formed the basis of the survey sent to the workshop participants. The attendees did suggest gathering use-cases from a broader set of individuals, such as scientists at different career stages.

Identify and maintain collaborations

- Identify other people and projects, both within and outside one's typical network or discipline. Includes identifying:
    - Collaborators and other strategic partners
    - Field work sites
    - Emerging model organisms and scientists using them
- Maintain established connections with colleagues
- Identify speakers for conferences (and potentially increase diversity)
- Find networking resources that target specific groups such as early career scientists, graduate students, and underrepresented groups
    - Networking aspect could have a positive influence on keeping individuals in science
- Look up an individual and find out what they are working on (publications, affiliations, associated projects, tools, etc.)

Resource awareness and training

- Identify available instruments, reagents, tools, and algorithms within a particular research area of interest or data type
    - Particularly useful to search for opensource resources and standardized protocols
- Training on the use of resources and best practices, which could be built into existing programs such as IBRO summer schools and INCF opportunities
- Survey to assess demand for training opportunities
- Exchange of developer-to-tester and user-to-user feedback, possibly via a community forum

Research topics and areas of interest

- Collectives or virtual communities around specific research questions, topics or tools
- On-going projects and programs that are not yet published or just in development
- Recent and popular publications, as an automated suggestion feature
- Mapping relationships between similar projects or datasets (e.g., via text mining or natural language processing)
- Landscape analysis of global neuroscience (and/or particular subfields)
- WebMD for neuroscience: for a specific neuronal type, the Inventory could link to many sources of information and compile

Data usage and reuse

- Catalog of metadata and metrics on available data
- Existing and planned data collections
- Data standards and harmonization
- Descriptions of data quality
- Accessing publicly available data

Transparency in funding

- Descriptors for allocated funding with matchmaking feature
- Identifying current funding opportunities
- Global analyses regarding where certain projects are currently being funded
- Descriptions of funding mechanisms in other countries, as to provide clarification for available opportunities

APPENDIX

PARTICIPANTS:

Co-organizers:

- **Melina Hale (USA)** – Professor and Vice Provost, University of Chicago, USA; Interim Co-Director, The Marine Biological Laboratory
- **Patrick Hof (USA)** – Professor, Icahn School of Medicine at Mount Sinai, USA

Attendees:

- **Christine Aicardi (UK)** – Senior Research Fellow, Human Brain Project Foresight Laboratory, King's College London, UK
- **Juan Belforte (Argentina)** – Principal Investigator; Vice-Director, IFBIO-Houussay Institute, UBA-CONICET, Argentina
- **Amy Bernard (USA)** – Product Architect, Allen Institute for Brain Science, USA
- **Jan Bjaalie (Norway)** – Professor, Institute of Basic Medical Sciences, University of Oslo, Norway; EU Human Brain Project Neuroinformatics Platform
- **Corrado Calì (Saudi Arabia)** – Research Scientist, Biological and Environmental Science and Engineering Division, King Abdullah University of Science and Technology, Saudi Arabia
- **Kim Cornish (Australia)** – Professor; Director, Monash Institute of Cognitive and Clinical Neurosciences, Monash University, Australia
- **Rui Costa (USA)** – Associate Director and CEO, Zuckerman Mind Brain Behavior Institute; Professor of Neuroscience, Columbia University, USA
- **Yves DeKoninck (Canada)** – Professor; Director, CERVO Brain Research Centre, Laval University, Canada
- **Anne Etgen (USA)** – Professor Emerita of Neuroscience, Albert Einstein College of Medicine
- **Satrajit Ghosh (USA)** – Principle Research Scientist, McGovern Institute for Brain Research; Assistant Professor, Harvard Medical School, USA
- **Glenda Halliday (Australia)** – Professor, University of Sydney, Australia
- **Hitoshi Hashimoto (Japan)** – Professor, Lab of Molecular Neuropharmacology; Graduate School of Pharmaceutical Sciences; Center for Child Mental Development; Institute for Datability Science; and Institute for Open and Transdisciplinary Research Initiatives, Osaka University, Japan.

- **Sean Hill (Canada)** – Director of the Krembil Centre for Neuroinformatics, The Centre for Addiction and Mental Health, Canada
- **Sandhya P. Koushika (India)** – Associate Professor, Department of Biological Sciences, Tata Institute of Fundamental Research, India
- **Roberto Lent (Brazil)** – Professor, Institute of Biomedical Sciences, Federal University of Rio de Janeiro, Brazil
- **Partha Mirta (USA)** – Crick-Clay Professor of Biomathematics, Cold Spring Harbor Laboratory, USA
- **Gaia Novarino (Austria)** – Assistant Professor, Institute of Science and Technology, Austria; Vice-chair of the FENS-Kavli Network of Excellence
- **Natalia Petridou (Netherlands)** – Associate Professor, Center for Image Sciences, University Medical Center, Utrecht, Netherlands
- **Jong-Cheol Rah (Korea)** – Head of Neurophysiology Lab, Korea Brain Research Institute, Seoul, Korea
- **Karen Rommelfanger (USA)** – Assistant Professor, Director, Neuroethics Program, Emory University, USA
- **Marcelo Rubinstein (Argentina)** – Superior Investigator of the National Council of Scientific and Technological Research of Argentina and Associate Professor, University of Buenos Aires
- **Stephen Strother (Canada)** – Professor of Medical Biohysics, University of Toronto
- **Michael Yassa (USA)** – Professor and Chancellor's Fellow, Director, UCI Brain Initiative, University of California, Irvine, USA

Observers/Non-researcher Participants

- **Mathew Abrams** – Head of Science and Training, International Neuroinformatics Coordinating Facility (INCF)
- **Amy Adams** – Director, Office of Scientific Liaison, National Institute of Neurological Disorders and Stroke
- **Stephanie Albin** – Science Program Officer, The Kavli Foundation
- **Linsday Borthwick** – Science Writer, The Kavli Foundation
- **James Deshler** – Deputy Division Director, Division of Biological Infrastructure, National Science Foundation
- **Kristin Dupre** – Scientific Content and Communication Strategist, Office of Scientific Liaison, National Institute of Neurological Disorders and Stroke
- **Caroline Montojo** – Director of Brain Initiatives and Science Program Officer, The Kavli Foundation

- **Sridhar Raghavachari** – Program Director, Integrative Organismal Systems, National Science Foundation
- **Edda (Floh) Thiels** – Program Director, Integrative Organismal Systems, National Science Foundation
- **Ashish Tonse** – President, Kaizen Consulting, Inc.
- **Eriberta Vasquez** – Research Support Assistant, The University of Chicago
- **Samantha White** – Science Communication and Coordination Specialist, Office of Scientific Liaison, National Institute of Neurological Disorders and Stroke
- **Mariela Zirlinger** – Editor in Chief, Neuron

RELATED PUBLICATIONS

Rafeal Yuste and Cori Bargmann, **Toward a Global BRAIN Initiative**, *Cell* 168, March 9, 2017 http:///dx.doi.org/10.1016/j.cell.2017.02.023

RESOURCES

The following resources were mentioned during the Workshop or in post-Workshop feedback.

Data Infrastructure / Schema

- Google structured data Structured data is a standardized format for providing information about a page and classifying the page content. Google uses structured data that it finds on the web to understand the content of the page, as well as to gather information about the web and the world in general.
- Schema.org A collaborative, community activity with a mission to create, maintain, and promote schemas for structured data on the Internet, on web pages, in email messages, and beyond. Founded by Google, Microsoft, Yahoo and Yandex.

Databases

- NIH RePORTER An electronic tool that allows users to search a repository of both intramural and extramural NIH-funded research projects from the past 25 years and access publications since 1980, and patents resulting from NIH funding.
- Neuroscience Information Framework (NIF) An initiative of the NIH Blueprint Consortium, which brings together 16 NIH Institutes, Centers and Offices that support

neuroscience research into a collaborative framework to coordinate their ongoing efforts and to plan new cross-cutting initiatives. Working together, they identify pervasive challenges in neuroscience and any technological barriers to solving them. NIF's **Discovery Portal** is an innovative semantically-enhanced search engine of the largest collection of neuroscience information that allows users to customize and refine their searches via NIF's terminologies.

- Dimensions A database platform developed by Digital Science that brings together grants, publications, citations, alternative metrics, clinical trials and patents. Includes free search and metrics for over 95 million articles.
- NeuroMorpho.Org A centrally curated inventory of digitally reconstructed neurons associated with peer-review publications, containing contributions from 400+ laboratories worldwide.
- Dryad Digital Repository An online repository for data underlying scientific and medical literature. This resource accepts a wide diversity of datatype and already has an embedded upload process with many journals.
- The Global Alzheimer's Association Interactive Network (GAAIN) An online integrated research platform, which links scientists, shared data, and sophisticated analysis tools.
- ELIXIR An intergovernmental organisation that brings together life science resources from across Europe, including databases, software tools, training materials, cloud storage and supercomputers.
- ResearchGraph An open collaborative effort toward connecting scholarly records across global research repositories.
- Cordis (Community Research and Development Information Service) The EU's primary public repository and portal to disseminate information on all EU-funded research projects and their results in the broadest sense.
- LONI (Laboratory for Neuro Imaging at USC) collect and analyze imaging, genetics, clinical, and behavioral data to better understand the brain's role in human health, disease, and changes across the lifespan. (Related: IDA – Image and Data Archive, powered by LONI, secure online resource for sharing, visualizing, and exploring neuroscience data.)
- Open Humans A platform and community that that enables individuals to upload, privately store, and connect their personal data (genetic, activity or social media) with research and citizen science.
- Force11 A community of scholars, librarians, archivists, publishers and research funders that has arisen organically to help facilitate the change toward improved knowledge creation and sharing.

- GoFair A bottom-up international approach for the practical implementation of the European Open Science Cloud (EOSC) as part of a global Internet of FAIR Data & Services
- Interfolio Faculty information system.

Research Organizations

- INCF (International Neuroinformatics Coordinating Facility) An independent international facilitator catalyzing and coordinating the global development of neuroinformatics, and advancing training in the field.
- IBRO (International Brain Research Organization) The global federation of neuroscience organizations that aims to promote and support neuroscience around the world through training, teaching, collaborative research, outreach and advocacy.

Personal Identifiers

- ORCID A not-for-profit that provides a persistent digital identifier to distinguishes researchers.

Data Sharing Policies

- FAIR A set of community-developed guidelines to ensure that data or any digital object are Findable, Accessible, Interoperable and Reproducible.

Funding

- Harnessing the Data Revolution (NSF) One of 10 research and process "big ideas" that will drive important aspects of NSF's long-term research agenda, push forward the frontiers of U.S. science and engineering research, and lead to new discoveries and innovations.