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**CNSB’s Timeline**

**From Opening in Oct 2017 to Present**

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
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<tbody>
<tr>
<td>2017</td>
<td>MAY – Andrew Emili recruited as CNSB Founding Director, effective July 1, 2017, with primary appointments in Biology (CRC) &amp; Biochemistry (BUSM)</td>
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<tr>
<td>2017</td>
<td>JUN – Strategic Plan, Mission, Values and Charter submitted to the University administration</td>
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<tr>
<td>2017</td>
<td>AUG – Charter signed</td>
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<td>2017</td>
<td>SEP – First Center staff hired; major equipment delivery, installation of Q-Exactive HF-X, Twitter launch, daily operations commence</td>
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<td>2017</td>
<td>OCT – Grand opening of the CNSB on Medical Campus, christened by University Provost and Dean of the Medical School</td>
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<tr>
<td>2018</td>
<td>APR – First quorum of Center Affiliates (associated faculty)</td>
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<td>2018</td>
<td>MAY – Rapid expansion of Center personnel, including first graduate students</td>
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<td>2018</td>
<td>JUN – Scientific Advisory Board assembled; installation of Q-Exactive HF</td>
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<tr>
<td>2018</td>
<td>JUL – Prof. Emili starts service on Biochemistry faculty mentoring and Biology APT Committees</td>
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<tr>
<td>2018</td>
<td>SEP – Presentations by first Invited Guest Speakers of CNSB; Prof. Emili tours new Dana-Farber cbio Center</td>
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<tr>
<td>2018</td>
<td>DEC – Secured funding for major federal grant (NIH), as well as Pilot award from J&amp;J Lung Cancer Alliance</td>
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<tr>
<td>2019</td>
<td>FEB – NIH R01/RF1 funding “Systems-level functional proteomics analysis of protein assemblies in Alzheimer’s disease and mouse models”</td>
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<tr>
<td>2019</td>
<td>MAR – NCI Cancer Systems Biology Consortium U01 Award; SAB at QBI Host Pathogen Mapping Initiative</td>
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<tr>
<td>2019</td>
<td>APR – Prof. Emili serves on ASMB Publication Committee</td>
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<tr>
<td>2019</td>
<td>JUN – Award NIH HEI S10OD026807 Ultra-High Precision Mass Spectrometer</td>
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<tr>
<td>2019</td>
<td>JUL – Prof. Emili serves on Biology Faculty Search Panel</td>
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<tr>
<td>2019</td>
<td>AUG – Exploris Instrument #1</td>
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<tr>
<td>2019</td>
<td>SEP – Biochem &amp; Biol Retreats</td>
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<tr>
<td>2019</td>
<td>OCT – Inaugural Center Symposium &amp; SAB meeting</td>
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<tr>
<td>2019</td>
<td>NOV – Co-sponsor BU GSI (Genome Science Institute) Symposium</td>
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<tr>
<td>2020</td>
<td>JAN – NIH funding R01 AG064932 “Genetic Modifiers of Protein Interaction and Propagation Networks in Tauopathy”</td>
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<tr>
<td>2020</td>
<td>FEB – Exploris Instrument #2</td>
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<tr>
<td>2020</td>
<td>MAR – Renewed funding from J&amp;J Lung Cancer Alliance</td>
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<tr>
<td>2020</td>
<td>APR – BU pauses non-essential research activities due to COVID Pandemic</td>
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<tr>
<td>2020</td>
<td>MAY – First PhD student graduates from CNSB</td>
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<tr>
<td>2020</td>
<td>JUN – Opening of Charles River Branch of CNSB, the Target Discovery Laboratory</td>
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<tr>
<td>2020</td>
<td>APR – New 5-yr NIH R01 Grant “Mapping Protein Interaction Networks Essential for Gonococcal Pathogenesis” award to Prof. Emili and team</td>
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<tr>
<td>2020</td>
<td>MAY – First In-Person Group Meeting in months</td>
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<tr>
<td>2021</td>
<td>JUN – Center 5-Yr Review (pending)</td>
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<tr>
<td>2021</td>
<td>SEP – First In-Person Group Meeting in months</td>
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<tr>
<td>2021</td>
<td>NOV – Center 5-Yr Review</td>
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Self-Study Narrative Outline

I. UPDATED CHARTER
The Center for Network Systems Biology’s Charter (updated) is provided in Appendix A.*

II. EXECUTIVE SUMMARY

Now entering its fourth year, CNSB is an academic “start-up” devoted to developing and implementing innovative mass spectrometry-based proteomic and allied bioinformatic approaches to reveal the molecular networks that drive cell biology and pathobiology. Human health, development and disease depend on dynamic networks of physical interactions among proteins and between proteins and other cellular components, such as metabolites and nucleic acids. These interactions mediate essential cellular functions, such as signal transduction in response to extracellular cues, infections, and other disease perturbations. Remarkably, the identity, composition, and cell-type specificity of these macromolecules remains largely unknown. Hence, CNSB addresses unmet needs of our partners, at Boston University (BU) and beyond, for systematic experimental and computational approaches to discover and explore these protein networks, and their small-molecule ligands, in different tissues, physiological states, and clinical disorders – such as cancer, infection, neurodegeneration and cardiovascular disease. To address the burgeoning demand for proteomic and associated data science solutions, in concert with our many collaborative partners (see Appendix B: Affiliated Faculty*), CNSB develops, deploys, and disseminates innovative experimental and computational approaches to advance the field of network systems biology.

CNSB’s doors opened just four years ago. It has navigated challenges (scientific and otherwise), particularly the COVID-19 pandemic, with an unwavering commitment to scientific excellence, trans-disciplinary collaboration, and enriching trainee-mentoring experiences. Serving as a bridge connecting multiple research groups and disciplines across the Charles River and Medical Campuses, the Center advances President Brown’s directive for a unified “One BU”. It also supports other enduring goals of the university’s strategic plan, including contributing to a vibrant, diverse and inclusive research community that seeks to advance fundamental understanding of human biology. During this time, Prof. Emili has led a dramatic increase in the size and quality of proteomics capabilities and initiatives at BU, enhancing trainee and faculty support and quadrupling its volume of research funding in four years.

CNSB’s funding model supports the Center’s unique approach to multi-disciplinary team science. This includes the establishment and operation of a quantitative, high-throughput, state-of-the-art mass spectrometry platform. The model is based on securing major external revenue streams with diverse long-term partners, with the ultimate aim of self-sufficiency. We expect to win funding from NIH multi-PI awards (R21/R01), larger multi-center team grants (RM1/U01), and substantive infrastructure awards (S10/HEI/SIG) from the National Institutes of Health (NIH), including the National Cancer Institute (NCI), and other federal funding bodies, such as the Department of Defense (DOD) and National Science Foundation (NSF). In addition, targeted awards have been obtained or sought from major industry sponsors (J&J, Merck), independent biomedical research foundations (CZI), and local pilot funding sources (CTSI).

CNSB and its affiliated faculty have enjoyed considerable success with this multipronged funding approach. Since its founding in 2017, CNSB director Andrew Emili has secured $6,364,632 in total grant funding, including $4,805,777 (direct and indirect) in grant awards from the NIH. The CNSB has grown its revenue sources fourfold from in its first year, and it aims to double its outside financial resources over the next four years. Through stable funding from the Office of Research, the Center leadership is supported in these efforts by highly capable part-time administrative staff, who provide professional services (grants management, secretarial support, procurement, social media outreach) in a timely, cost-effective, and efficient manner.

This self-study summarizes CNSB’s operational growth, scientific goals and challenges, and overall scholarly activity and impact over the last four years. Despite constraints imposed by the pandemic, the Center has faithfully followed its initial Charter, which is fully in line with the new University strategic plan by contributing to a vibrant, diverse and inclusive research community, supported by world-class interdisciplinary scientific capabilities to advance the fundamental understanding of human biology and health.

* Appendix A is the collection of confidential attachments shared by email alongside this self-study report
* Please note the appendices have been removed from the public version
III. OVERVIEW – CONTEMPORARY ISSUES, RESEARCH VISION AND PROGRAM DIRECTION

“A hidden connection is stronger than an obvious one”
- Heraclitus of Ephesus 535–475 BC

Biomedical research is at a crossroads. Tremendous advances in technology promise to revolutionize medicine, biotechnology and pharmacology, but daunting obstacles lie ahead, including an increasingly competitive funding environment, an ageing population, the slowed growth of drug development pipelines, and the potential for future pandemics. Accordingly, there is a need for greater translational impact from current research investments. Despite the groundswell of “omic” and “big data” science, it is imperative to analyze biological specimens comprehensively, with speed, rigor and quantitative accuracy. Precision mass spectrometry is a powerful enabling technology for building this research enterprise. In this context, CNSB is poised for continued scientific impact and future growth. Analytical excellence, technology development, and the Center’s record of productive partnerships in exciting new research areas will help it to build and sustain its unique identity in an increasingly crowded landscape.

We started out entrepreneurial, and plan to stay entrepreneurial. CNSB has established a highly productive platform centered on quantitative mass spectrometry, an enabling technology for systems biology, to enhance the BU research enterprise. We are not a service facility, but rather we engage in mutually fulfilling research partnerships. CNSB aims to foster scientific innovation, collaboration, and interdisciplinary research by harnessing advances in functional proteomics, data science and systems biology. For example, we are working closely with synthetic biologists at the Biological Design Center to map and manipulate the signaling pathways that drive hypertrophic cardiomyopathy (leading to sudden cardiac failure) and T cell exhaustion (associated with immuno-oncology and the clinical response to checkpoint therapy).

We are a speed boat, not an aircraft carrier. To this end, CNSB deploys an array of enabling experimental technologies, most centered on precision mass spectrometry and integrative data analysis pipelines, to generate valuable biomedical findings and public datasets in collaboration with a multitude of affiliated faculty on both BU campuses. CNSB aims to be nimble, taking advantage of emerging local opportunities, as well as connections to pharma, biotech and our bigger academic units across the Charles (rather than being overshadowed by them). Instead of focusing on competition for our trainees and staff from the entrenched deep pockets of industry, CNSB aims to be a magnet for trainees and biotech partnerships.

We are building links to biotech. Notably, we have just completed the first year of a jointly mentored postdoctoral fellowship with the Merck Exploratory Science Center, focused on SARS-CoV-2 spike-protein mediated human receptor engagement and entry into susceptible human cells with our partners at BU’s National Emerging Infectious Diseases Laboratories (NEIDL). In addition, we have just successfully concluded a two-year sponsored research agreement with Johnson and Johnson investigating a novel model of initiation of human lung carcinoma with Prof Darrell Kotton and colleagues at the BU Center for Regenerative Medicine (CReM). These alliances with biotech bring additional resources and CNSB seeks to train future generations of biotech leaders as part of our mission. The Center also actively disseminates our talent and resources to the broader global scientific community in several ways: by publishing high-impact peer-reviewed research publications; distributing open-source code, datasets and web-based tools to stimulate scientific progress; and conducting training, mentoring and outreach activities on both BU campuses to advance the skills, competency, and versatility of next generation leaders versed in systems biology concepts, proteomics approaches, and integrative data science strategies.

We continue to grow. Given that CNSB’s mandate is to support biomedical discovery at BU in an inclusive, forward-looking manner, the Center’s approach to scientific engagement calls naturally for innovation and experimentation with different types and structures of scholarly collaboration. To date, the Center has engaged productively in collaborative projects with over 30 affiliated faculty (see Appendix B) representing over a dozen university departments and academic programs on the Charles River and Medical School Campuses. These efforts are typically multi- or even inter-disciplinary, and often at the cutting edge; for example, working with Prof Aaron Beeler and other synthetic chemists in the BU Dept. of Chemistry and Prof David Boas and expert spectroscopists at the BU Photonics Center, CNSB is developing new fluorescent imaging technology to sequence proteins in a massively parallel manner. These collaborations provide new avenues of exploration, while other collaborations reinforce areas of existing strength at BU, particularly in the fields of neurobiology, cancer biology, microbiology, bioinformatics, bioengineering and synthetic biology. Beyond partnership with other senior leadership, CNSB has initiated exploratory collaborations with 12 junior faculty (assistant professors and research faculty), particularly recent recruits to BU, such as Profs Mohsan Saeed and Florian Douam in virology, and Profs. Dennis Jones and Raphael Szalat in oncology.

We have an entrepreneurial approach to scientific engagement. Given the large and growing number of collaborative projects and our unique scientific capabilities, CNSB has emerged as a significant driver of grant submissions for 38 of our affiliated BU laboratories. Our operational flexibility enables us to engage with experts in many academic domains, encompassing chemistry, structural modeling and
CNSB’s footprint is evolving. While formally overseen by the Office of Research located on CRC, the Center’s main laboratory, housing the bulk of its advanced LC/MS instrumentation, is present on the Medical School Campus, where the CNSB occupies over 2,500 sq. ft. of fully renovated space, housing 80% of the Center’s infrastructure and core personnel. Since its inauguration in October 2017, CNSB’s scientific resources have grown considerably, particularly over the past two years (2020-21), with the acquisition of three powerful new LC/MS instruments. These include two workhorse high-performance ThermoFisher Exploris 480 mass spectrometers, housed in the Conte/K Medical Research Building, and one flagship ThermoFisher Orbitrap Eclipse Tribrid mass spectrometer, secured through a High-End Instrumentation (HEI) grant from the NIH to Prof. Emili, Prof. John Porco (chemist, and Director of the BU Center for Molecular Discovery) and other CNSB members in 2020. It is housed in our new Target Discovery Laboratory in the CRC’s Life Science & Engineering Building.

Divide and Concur. Cognizant of the challenges of managing two physically distanced facilities, the Center’s leadership aims to spread the research activities, technical capabilities and affiliated faculty engagement equitably across the two campuses. Since CNSB is not a traditional departmental unit, it is unfortunately not able to formally hire new faculty candidates to its ranks; rather, it works within traditional departmental hiring structures to influence the recruitment process in a synergistic manner, leveraging its world-class infrastructure, collaborative spirit, and unique research capabilities to attract talented candidates. In this vein, CNSB Director Andrew Emili has served on several past and ongoing search committees as well as performed significant additional academic service such as faculty advancement for departments on both campuses. This has facilitated the recruitment and retention of accomplished faculty, vigorous new graduate students, postdocs and qualified staff.

Program direction: To achieve the overarching mission of CNSB — to apply innovative experimental and computational approaches to discern macromolecular interactions critical to the fundamental operation of biological systems of broad interest to biomedicine — the leadership is pursuing a multipronged research program articulated around three core themes:

**Theme 1: Mapping macromolecular networks essential to human health and disease.**

The human genome encodes thousands of proteins that catalyze the generation of metabolites, relay signals, and form the dynamic molecular architecture of the different cells and organs of the body. These networks act in harmony in healthy cells and tissues; this balance is disrupted, first locally and then globally, in disease states. To map these dynamic networks, CNSB is deploying methods such as targeted protein tagging, high-resolution structural modeling, and quantitative mass spectrometry, to selectively label, enrich and topologically define the functionally and physically linked proteins in particular organelles (such as at neuronal synapses) in animal and cell-based models of human pathology. By deploying multidisciplinary approaches and complementary methods, CNSB researchers aim to define physical interaction networks relevant to human health and disease. This includes exploring the:

i. Dynamic regulatory networks of tissues, cells and subcellular compartments that determine cell state (phenotype).

ii. Activation of protein kinase-mediated signal transduction pathways that are dysregulated in pathologies such as cancer, heart failure and neurodegeneration.

iii. Host–pathogen interfaces of viruses and other pathogens that cause clinically important human infections.

With our growing network of academic, clinical and industry collaborators, CNSB is making substantive progress towards these objectives. With our affiliated faculty, CNSB is generating meaningful insights from the thousands of functional associations discovered, documented, and characterized over the past four years. This work has led to multiple high-impact papers, including a major multi-team report in *Molecular Cell*. We reported how an inter-disciplinary team assembled by the CNSB used quantitative phosphoproteomic profiling to survey induced pluripotent stem cell-derived alveolar epithelial type 2 cells infected with SARS-CoV-2 at air–liquid interface; this effort revealed virus-induced remodeling of respiratory-specific processes, highlighting potential novel therapeutic avenues that we validated by targeted small molecules. This work has opened up additional new project directions and grant submissions with other virology and bioengineering groups at BU and beyond.
**Theme 2: Data interpretation and clinical translation.** Because aberrant protein function is a root cause of virtually all pathologies, other ongoing interaction mapping efforts of the Center are aimed at increasing fundamental understanding of the causal molecular basis of other diseases, most notably neoplasms, cardiovascular disease, and brain disorders.

As a founding member of BU’s new Faculty of Computing and Data Sciences, CNSB Director Emili aims to leverage innovative bioinformatics approaches, such as deep learning, to process, analyze and integrate the proteomics data CNSB generates into probabilistic networks to infer the biomedical relevance of the dynamic protein interactions and multi-protein complexes the Center discovers. By combining this information with genomic, clinical, and structural biology projections, the Center also prioritizes candidate macromolecules for in-depth, follow-up investigations with our affiliated faculty members to confirm key biological predictions. For example, the Center has been using functional proteomics to document previously overlooked regulatory pathways, including protein kinases and sequence-specific transcription factors that drive T cell dysfunction arising during chronic inflammation, infection, and cancer. We will continue to develop and apply integrative computational tools to combine protein expression, modification, and interaction data with additional independent evidence (such as metabolomic and genomic profiling results, including messenger RNA profiles), together with structural models and other types of information, to illuminate causal functional connections driving the cell’s molecular machinery. Ultimately, through its growing cadre of clinical and industry partners, CNSB aims to translate the mechanistic knowledge we obtain from our QS*AR (Quantitative Systems-Activity Relationship) modeling approach into new therapeutic leads.

**Theme 3: Leadership, service and mentoring.** Through its dedication to training, mentoring, and teaching, CNSB aims to build a sustainable, multidisciplinary program that attracts the brightest minds in experimental and computational biology and prepares them to solve some of the most vexing problems in systems biology and medicine. These young researchers will collaborate with some of BU’s best scientists to build connectivity diagrams illuminating the protein interactions underlying human health and disease. The resulting talent, resources, and research contributions will propel CNSB as a leader in the field.

**In comparison:**

Given its proven leadership and intellectual and technological resources, the CNSB is uniquely poised to fulfill the burgeoning demand among US researchers for enabling functional proteomic, chemical proteomic, and structural proteomic approaches to study the molecular biology of important biological systems and disease states, including infection by highly contagious viruses. While other peer centers and universities have considerable expertise in mass spectrometry, proteomics, systems biology, and biomedicine, few currently offer the necessary breadth, depth and infrastructure capacity needed to map human interactomes on a proteome-scale in as many different biomedical contexts as does CNSB. Our Center offers unique advantages required for addressing scientific questions, including: sample preparation from limiting clinical specimens, adapting workflows for infectious samples, non-denaturing preparative techniques upstream of LC/MS (such as biochemical resolution of multi-protein complexes for co-fractionation-based correlational profiling), and downstream computational analysis for inference of protein–protein interactions by machine learning. Hence, CNSB addresses unmet needs at BU and is unique in comparison to other prominent proteomics centers and NIH-P41 grant-supported National Research Resources, such as:

- **Taplin Mass Spectrometry Facility**
  Harvard University; PI: Steven Gygi  
  The Taplin is a core facility for the analysis of proteins and peptides by mass spectrometry. The facility is focused on serving the needs of investigators at Harvard Medical School and the Harvard-affiliated Institutions (Dana Farber Cancer Institute, Children’s Hospital, Massachusetts General Hospital, Brigham and Women’s Hospital, and Beth Israel Deaconess Medical Center). CNSB is unique in comparison to Taplin since our focus is on supporting BU faculty, as well as on technology development to map the interaction biology of non-traditional models and tissues.

- **National Center for Dynamic Interactome Research (NCDIR)**
  Rockefeller University; PI: Michael P. Rout, PhD  
  NCDIR combines expertise in cell biology, genetics, mass spectrometry, and computational structural biology to develop new integrated approaches for detecting, isolating, and analyzing select macromolecular complexes. CNSB differs from NCDIR since our focus is on technology development to map out the interaction biology of entire cells.

- **National Center for Quantitative Biology of Complex Systems**
  University of Wisconsin-Madison; PI: Joshua J. Coon, PhD  
  The NCQBCS is developing next-generation protein, metabolite, and lipid measurement technologies for a wide variety of biomedical applications and making whole omic analysis faster and broadly accessible. The CNSB has good relations with NCQBCS Director Josh Coon and agreement on the complementarity of our respective Center mandates.
• National Resource for Translational and Developmental Proteomics
Northwestern University; PI: Neil L. Kelleher, PhD
The NRTDP is dedicated to studying protein molecules by intact protein mass spectrometry. CNSB aims to build interactome networks from the ‘bottom up’, while NRTDP uses a complementary ‘top down’ approach.

• Proteomics Research Resource for Integrative Biology
Pacific Northwest National Laboratory; PI: Richard D. Smith, PhD
PRRIB develops and integrates new proteomic technologies for use in biomedical research, with an emphasis on high-resolution, quantitative approaches. CNSB is unique compared to PRRIB since our focus is on applying technologies to map out the protein interactomes of cells and tissues.

• Resource for Native Mass Spectrometry Guided Structural Biology
Ohio State University; PI: Vicki H. Wysocki, PhD
The RNMSGSB is building an integrated MS-based workflow for intact, native complexes, i.e., “complex-down” characterization using innovative scientific instrumentation and computational tools. The CNSB is unique compared to RNMSGSB since our focus is on mapping out the interaction biology of non-standard cell models and tissues on a proteome-wide scale.

• Center for Computational Mass Spectrometry
University of California, San Diego; PI: Pavel Pevzner, Vineet Bafna, Nuno Cabrita.
This Center focuses on the computational bottlenecks that impair the interpretation of data, bringing modern algorithmic approaches to mass spectrometry and building a new generation of reliable, open-access software. The CNSB is unique compared to CCMS since our focus is on generating experimental data and using computation to define cellular protein networks post-LC/MS data processing.

IV. ASSESSMENT OF SCHOLARLY IMPACT

1. Evaluate the scholarly activities of the center:

1.1 What is its research mission?

The Center for Network Systems Biology is a university-wide Center that develops and applies powerful research capabilities in functional proteomics and quantitative mass spectrometry to solve fundamental biomedical questions in often complex and non-traditional cell models or tissue settings. CNSB’s mission, honed via a multitude of productive collaborations with affiliated BU faculty since 2017, focuses on the experimental characterization of the physical networks of proteins and protein macromolecular complexes present in cells and tissues in different pathophysiological contexts. While advances in genomics provide essential information about protein-coding genes, a critical challenge is to understand how the resulting protein products of these genes function together to mediate cellular processes, such as growth and development and how their interactions often become perturbed, leading to disease. CNSB’s core scientific goal is to produce ‘connectivity’ diagrams of unprecedented scope, quality, and resolution that reveal the dynamic physical, and functional, molecular organization of healthy cells and diseased tissues, and to use these maps to identify the fundamental mechanisms driving normal human cell biology and how their disruption leads to pathology. This fundamental knowledge empowers our basic biology affiliates and informs our clinical, chemistry, and biotechnology partners in their quest to devise rational therapeutic solutions to counter disease progression.

1.2 Who are its members?

CNSB’s best asset is the network of relationships our Center has formed with researchers at both BU campuses. Currently, the Center engages affiliated faculty, staff, postdoctoral fellows, graduate students and undergraduates from 12 schools, colleges, departments and programs, across both the Charles River and Medical campuses. These include forging strong collaborations with the Directors and faculty of the BioDesign Center, the Center for Regenerative Medicine, and the National Emerging Infectious Diseases Laboratories. For more details regarding the members and scientific interests of our faculty affiliates, explore Appendix B. Notable examples of CNSB driving inter-disciplinary engagement include our central role in linking the structural biology group of Prof. Sandor Vajda with the lead of the BU Microbiome initiative, Prof Daniel Segre. This team is developing a major new grant proposal focused on the systematic discovery and characterization of bioactive compounds from microbes in the human gut and their impact on host transcription factors (nuclear receptors) and, ultimately, on human health. CNSB’s consortium of engaged academics has evolved and grown significantly over each of the past four years, even during the pandemic. CNSB’s leadership is passionate about multidisciplinary (additive) and interdisciplinary (synergistic) collaborative research. It is always open for new business and engages regularly in mutually beneficial opportunities that resonate with the Center’s mission, capabilities and strategic goals.
1.3 What have been its major contributions to the field?

CNSB’s collaborative research program is prolific and is starting to generate high-impact joint publications. CNSB’s core faculty leadership are senior or co-senior authors on over 50 peer-reviewed publications published since the foundation of the Center four years ago; the papers have collectively accumulated over 860 citations, or approximately one collaborative paper with a moving average of 17 citations each per month. While acknowledging that some of the papers published recently report research originating or partly performed by Prof. Emili back in Toronto, this sizeable body of work also provided a foundation for CNSB’s rapid startup at BU and these and other publications originating from our BU address give immediate visibility to the CNBS as it looks for peer recognition. A complete listing of all scholarly manuscripts (peer-reviewed articles and preprint submissions) involving CNSB core faculty, staff, trainees, and one or more of our Center affiliates or other collaborators at BU produced since 2017 is provided in Appendix C (Publication Spreadsheet). Notable external collaborators on joint publications include distinguished researchers from other prominent Boston-area research institutions, such as Harvard, as well as other noted scientific institutions, such as the University of Toronto, reflecting the Center’s established and growing network of global interdisciplinary collaborators.

1.3.1 Number of scholarly, peer-reviewed publications coauthored by two or more center/institute members

As highlighted in Appendix C (Publication Spreadsheet), over a dozen publications were co-authored by two or more affiliated faculty, including at least one Center core member. Notable examples include a global map of soluble and membrane-associated protein complexes in the mammalian central nervous system (“BrainMap Elucidates the Macromolecular Connectivity Landscape of Mammalian Brain” published in Cell Systems). The paper is based on a fruitful (and ongoing) collaboration with the neurobiologist Ben Wolozin (Pharmacology and Experimental Therapeutics); we used functional proteomics methods and computer learning to document the distribution of over 1,000 multi-protein complexes in the mammalian brain in normal and pathophysiological contexts. With a dozen citations in 2021 so far, this work builds on previous publications by the Emili lab in human (“A census of human soluble protein complexes”, Cell, 748 citations), and other animal models (“Panorama of ancient metazoan macromolecular complexes”, Nature, 372 citations). Since then, we have co-authored another six joint publications with the Wolozin group, focusing on functional proteomic analysis of models of Tauopathy and Alzheimer’s disease, all in print within the past year. Multiple additional manuscript co-submissions are pending over the coming months.

Other notable publications driven or co-authored by at least two CNSB members providing timely insights into basic biology and disease mechanisms include Hekman et al., “Actionable Cytopathogenic Host Responses of Human Alveolar Type 2 Cells to SARS-CoV-2”, a rapid response team effort involving affiliated faculty in the BU National Emerging Infectious Diseases Laboratories (NEIDL; Mühlberger, Saeed, Davey), Center for Regenerative Medicine (CReM; Kotton, Wilson), and CNSB, published in Molecular Cell in Dec 2020. Here we used quantitative phospho/proteomic profiling to define the responses of human primary-like alveolar cells to infection and viral disruption host programs. We leveraged this dataset to discover antiviral drug targets, including five compounds potently inhibiting viral replication by >90% in human lung cells, of which four showed no/weak efficacy in Vero E6 cells (a monkey kidney cell line used by many researchers in the field).

Finally, we plan to submit a foundational paper based on an inter-disciplinary effort between CNSB and a large team of structural modelers, analytical chemists, and metabolic systems biologists at BU and beyond; we are defining the physical interaction networks of endogenous small molecule metabolites with each of the essential protein enzymes and transcription factors of the bacterium E. coli with unprecedented scope (cellular scale) and detail (probabilistic atomic resolution). We anticipate this paper will be published in a top tier journal and have a major impact on the chemical proteomics field.

1.3.2 Proposals submitted and funded from extramural sources with two or more members as collaborators

Through joint scientific initiatives and other forms of non-financial collaboration, CNSB has been a lead or major co-applicant on over 120 external grant submissions since 2017 (see Appendix D), most targeting federal agencies, of which funding was awarded for roughly one quarter. External funding was secured from diverse organizations include NIH, NSF, and NCI, totaling $6,222,115 to the core CNSB leadership.

1.3.3 Patents submitted and funded from extramural sources with two or more members as collaborators

CNSB currently has two pending provisional patent submissions (one on a novel composition of matter, one on process claims) pending for the USPTO, based on joint inventions with BU Chemistry Prof. Aaron Beeler and members of the BU Photonics Center. The applications describe potentially transformative new florescent dyes designed for imaging-based, massively parallel next-generation protein sequencing.
1.3.4 Number of different Center/institute members associated with the results above (e.g., if 20 co-authored papers all have same two people only, then Center is not facilitating a broad community of collaborations)

Since 2017, CNSB has co-authored publications and grant submissions with over two dozen different affiliated BU faculty and has manuscripts and grant proposals pending with another 12 PIs, resulting in co-publications with at least five dozen different BU personnel (faculty, staff and trainees) by year’s end.

1.3.5 PhD students who were supervised by two or more members (with one as primary supervisor)

While serving on the graduate student committees associated with 20 BU faculty members, CNSB Director Emili currently co-supervises eight doctoral students with at least one other affiliated faculty member:

- Mr. Jarrod Moore, MD/PhD student supervised within the Multicellular Design Program together with bioengineer Prof. Chris Chen, Director of the BioDesign Center
- Mr. Alejandro Rondon Ortiz, PhD student co-mentored in the Neurobiology Graduate Program with neurobiologist Prof. Ben Wolozin;
- Mr. Matthew Lawton, PhD student co-mentored in the Program in Biomedical Sciences with synthetic biologist Prof. Wilson Wong;
- Mr. Stanley Goldstein, PhD student co-mentored in the BioMolecular Pharmacology Training Program with neurobiologist Prof. Camron Bryant;
- Ms. Samantha Clayton, PhD student co-mentored in the Bioinformatics Program with computational biologist Prof. Stefano Monti;
- Mr. Neal Kewalramani and Mr. Ahmed Youssef, two PhD students co-mentored in the Bioinformatics Program with computer scientist Prof. Mark Crovella; and
- Mr. Ben Fitzsimmons, PhD student co-mentored in the BU Biomedical Engineering Graduate Program with synthetic biologist Prof. Ahmed (Mo) Khalil.

1.3.6 Proposals and funded “center-like” grants such as PhD or Post-Doc training grants, core facility instrumentation grants, multi-institutional grants with two or more BU members on them etc.)

CNSB Director Emili is a co-applicant/faculty member on five successful PhD/Postdoc training grants:

- T32 Predoctoral Training in Bioinformatics and Computational Biology;
- T32 Synthetic Biology and Biotechnology (SB2) Predoctoral Training Program;
- T32 Predoctoral Training Program in Cardiovascular Biology;
- T32 Predoctoral Training in Biomolecular Pharmacology;

CNSB core and affiliated faculty (Emili, McComb, and Porco) are also the recipients of $1,159,106 in funding in 2020 from the NIH (1 S10 OD026807; PI: Emili) for an “Ultra-High Precision Mass Spectrometer”. This grant supported the acquisition of high-end instrumentation to identify the molecular targets of drugs and other bioactive ligands in a major, multi-laboratory, multi-disciplinary effort involving the Departments of Chemistry, Biology, Bioengineering and other affiliated faculty at BU.

1.4 What are its measurable outcomes that provide added value beyond what is or can be accomplished within traditional departments?

Within its mandate to spur on inter-disciplinary work that empowers and bridges faculty across the two BU campuses, our Center's greatest strength lies in our ability to forge new collaborations that connect scientific leaders in different disciplines. CNSB is forming, nurturing and capitalizing on these connections through a variety of dynamic mechanisms, including active outreach and word of mouth. Unlike traditional academic units, such as departments, our focus is squarely on assembling and working with a diverse network of academic experts to address important challenges from outside disciplines, while attracting in new scholars, particularly junior faculty members, to create synergistic initiatives that play to BU's potential for scientific innovation, leadership, and impact.

Systems biology is one emerging strength at Boston University that is poised to become a cornerstone of the modern scientific enterprise in the post-pandemic era. CNSB empowers solutions to this challenge by embarking on collaborative multi-disciplinary studies and
supporting innovative research, training, and technology development across both university campuses. To maximize CNSB's scientific role and ensure the Center's long-term success, our projects in this community are centered on assembling and supporting outstanding teams of internationally renowned biologists, computer scientists and biotechnologists that work collectively to support basic knowledge discovery and eventual clinical translation. For example, to pinpoint the maladaptive impact of changes in cardiac protein networks in response to cardiovascular stress, such as hypertrophic cardiomyopathy and fibrosis, CNSB has been working closely with the Tissue Microfabrication Lab led by Prof Chris Chen, Director of the BU BioDesign Center, as well as with cardiobiologists at the Whitaker Cardiovascular Institute, Tufts University, Harvard Medical School, and beyond, to integrate state-of-the-art functional proteomic assays, new iPSC-derived human cell models, and clinical specimens to establish pathophysiological mechanisms. We likewise engage with clinician scientists, such as Dr. Vipul Chitalia, an attending nephrologist on the BU Medical Campus, to evaluate candidate markers predictive of impaired cardiac output in patients undergoing long-term dialysis.

Since our long-term plan is to illuminate protein networks in different cells and organs in other disease contexts—such as cancer and neurodegeneration, leading causes of mortality whose etiology and progression are still poorly understood—CNSB strives to assemble diverse multi-disciplinary partnerships through productive working relationships with renowned basic biology, applied biology, and clinical-oriented affiliated faculty and our industry partners, to generate human protein 'connectivity' diagrams of unprecedented quality, scope and utility. Beyond providing access to its powerful proteomic technology platform, CNSB plays a central role in bringing together researchers across different departments, disciplines, and capabilities, coalescing efforts into synergistic new directions. Spearheading these value-added efforts, CNSB's leadership strives to break down the traditional boundaries of conventional academic silos with the goal of establishing BU as a leader in inter-disciplinary molecular biology. For example, by combining structural and metabolic modeling with our colleagues in biomedical engineering with our own technical advances in chemical proteomics (through the systematic isolation of endogenous small molecule ligands), we have recently achieved something never attempted on as large a scale.

As a means of maximizing the scholarly impact of these tools and resources, and our Center's return on investment more broadly, we aim to translate our work beyond high-impact publications (which we note are largely open source) by creating additional valuable publicly accessible community resources: such as depositing our datasets into public repositories, creating individual project portals on the web that have hundreds of page views per week, and providing unfettered access to documented, open source computational tools via GitHub and other venues. Our staff has deep experience creating and maintaining web portals for sharing, visualizing, and analyzing project data and protocols obtained through various collaborative projects. For example, we have posted protein interaction network maps identified by Center technologies for human, mouse, other models, and most recently SARS-Cov-2, with sizeable community interest (tracking data below):

<table>
<thead>
<tr>
<th>Human Dataset Website</th>
<th>Mouse Dataset Website</th>
</tr>
</thead>
<tbody>
<tr>
<td>21,496 page views</td>
<td>3,857 page views</td>
</tr>
<tr>
<td>7,156 users</td>
<td>616 users</td>
</tr>
</tbody>
</table>

Our website – [cnsb.bu.edu](http://cnsb.bu.edu) – recently underwent a re-design to improve user experience, update resources and databases, and highlight the experiences of our members and trainees in their own voices. As part of the overhaul, analytics were set up to track viewer engagement and help us to better tailor content to our audience over the coming years.

To further community uptake of our Center's technologies, CNSB also actively disseminates timely notices highlighting the release of scientific publications, available technical presentations, and recently reported protocols and reagents, through our Center's main website and via Twitter and other social media.

In early 2021, the CNSB redoubled efforts to increase its engagement with Twitter. As a result, we have seen a 416% increase in hits to our Twitter page with an average of 4,800 page views per month, and a steadily improving (57% increase over 2020) follower count. The CNSB currently averages five original tweets per month, and content includes a mixture of spotlights of our students and researchers, publication announcements, and reposts of critical research of interest and import to our scientific community.
Our Twitter follower numbers are comparable to other Centers in the sciences at Boston University:

<table>
<thead>
<tr>
<th>Center</th>
<th>Twitter Follower Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neurophotonics Center</td>
<td>152</td>
</tr>
<tr>
<td>Biological Design Center</td>
<td>292</td>
</tr>
<tr>
<td><strong>Center for Network Systems Biology</strong></td>
<td><strong>390</strong></td>
</tr>
<tr>
<td>Center for Information Systems Engineering</td>
<td>406</td>
</tr>
<tr>
<td>Nanotechnology Innovation Center</td>
<td>506</td>
</tr>
<tr>
<td>Kilachand Center</td>
<td>540</td>
</tr>
</tbody>
</table>

(Twitter followers as of September 2021)

1.5 Describe the Center’s impact both inside and outside of the University

CNSB exerts a positive overall impact on the broader BU research community through its extensive and productive engagement with different academics and scientific communities located on both campuses, and by bridging multiple faculty, staff and trainees across traditional departmental and college structures. Despite the constraints of the past 18 months, we also currently provide computational guidance (virtual tutoring) as well as on-site, in-person wet-lab training to a dozen members from other collaborating laboratories at BU. More generally, we provide the BU community with timely access to specialized infrastructure without charge, and we generate valuable data in an efficient manner for papers and grants. We also share the repertoire of tagging plasmids, expression vectors and other valuable reagents created by our staff and trainees, and we teach advanced graduate-level courses in the areas of proteomics, mass spectrometry, and systems biology.

By forging diverse teams composed of leading academic faculty affiliates, CNSB fosters interdisciplinary research excellence at BU. Emerging team projects illustrating innovation and competitive advantage include CNSB’s role in investigating the regulatory pathways underlying immune/T cell exhaustion in reconstituted models of the tumor microenvironment with breast cancer biologist Gerald Denis and computational biologist Stefano Monti on the Medical Campus, and with the systems biologist Trevor Siggers and synthetic biologist Wilson Wong on the Arts and Sciences campus. CNSB also provides access to enabling technologies to address important research questions. For example, we are implementing powerful new photo-proximity protein labeling technology developed by our chemical biology partners at Merck to study the physical interactions of SARS-CoV-2 with receptors on the cell surface of pluripotent stem cell-derived primary-like human cells; the cells were generated by our regenerative biology colleagues at the CReM and BDC following time course viral infections performed by expert virologists at the NEIDL. As a community-centric Center, CNSB broadens the university’s scientific perspectives, creating new scientific opportunities that attract future joint-funding resources.

While many of our immediate scientific activities are focused on the needs of our collaborating faculty affiliates, our long-term objective is to distribute and refine the validated approaches obtained from our collaborative work with DBPs across the US. With our proven track records in proteomics and bioinformatics technology development, scholarly achievements, and training of highly qualified personnel, CNSB’s unique scientific capabilities and achievements attract increasing regional, national and international recognition: as evidenced by the growing number of external groups interested in partnering with us, invitations to contribute to local, national and international grant review panels and peer-reviewed journals, and requests to participate in scientific conferences and workshops. CNSB is becoming a recognized leader in the broader proteomics and systems biology research communities, appreciated for our commitment to analytical excellence, our advanced methods development, and our productive partnerships with other leading academic centers (e.g., Harvard Medical School and affiliated hospitals) and industry partners (e.g., Merck, J&J). CNSB affiliates have given dozens of scientific presentations.
at regional and national conferences and workshops, highlighting our scientific capabilities. Our strategic partnerships with the Slavov group at Northeastern and faculty in other major local academic institutions, such as Harvard, MIT, Tufts, and other research hubs in the Boston/Cambridge Area also place us in an especially impactful position to serve current and future unmet needs of the US research community. CNSB actively communicates project-related findings, protocols, notable Center activities, and pending events on a regular basis through social media and other outreach mechanisms, with the aim that the broader research community can confidently and appropriately access the validated technologies, quality datasets, and biomedical knowledge the Center generates.

CNSB makes concerted efforts to get the national research community interested and involved in our work. We make announcements on social media to bring attention to the people, projects, technologies, and resources developed by our Center. As part of an inclusive strategy, we use Twitter to document the diversity of Center personnel, the activities of URMs, and the public availability of the tools, training videos and datasets we generate. We have devised quantifiable metrics to measure the success of each of our dissemination efforts, including plans for tracking requests for collaboration, access to and citation of our Center’s technology platform, and utilization of the other resources provided by our staff. Other metrics for determining community engagement and wider impact of include: regular monitoring of web-page access; tracking publication citations; measuring attendance at sponsored meetings and workshops; and tracking records of collaborative project requests, total numbers of sample submitted to the Center LC/MS facility for analysis (as shown in table below), requests for training, and collaborative grants submissions.

<table>
<thead>
<tr>
<th></th>
<th># of LCMS Runs</th>
<th># of Raw Files</th>
<th>Total Terabytes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nov 2017 to Oct 2018</td>
<td>409</td>
<td>5707</td>
<td>4.802</td>
</tr>
<tr>
<td>Nov 2018 to Oct 2019</td>
<td>850</td>
<td>15829</td>
<td>17.019</td>
</tr>
<tr>
<td>Nov 2019 to Oct 2020</td>
<td>688</td>
<td>13509</td>
<td>11.842</td>
</tr>
<tr>
<td>Nov 2020 to present</td>
<td>538</td>
<td>16038</td>
<td>13.309</td>
</tr>
</tbody>
</table>

The excitement of the emergent BU systems biology community, including researchers on both campuses, drives the uptake of advanced proteomics and interactomics technologies offered by CNSB, including protocols and reagents optimized to the systematic study of protein interactions in model systems. This uptake is supported by online technical training videos, instructive bioinformatics software, and trainee testimonials. CNSB issues instructive annual reports and occasional media pieces that showcase our scholarly achievements, and the benefits and practical applications of the technologies we develop to the lay public. By serving on editorial boards and contributing to national and international professional societies, CNSB-affiliated faculty also seek to enhance the dissemination of our research findings, promote data sharing, and provide unfettered access to our open-source software. We are also submitting provisional patents of exciting new single cell spatial proteomics technology our Center is developing, which has potential industry applications.

1.6 Describe faculty quality indicators for associated faculty of the research unit including major prizes and awards, membership in national academies or honor societies, “young investigator” awards, journal editorships; describe nature of distinctive service, outreach and engaged scholarship

Many of the distinguished faculty members affiliated with the CNSB are internationally recognized researchers, and many have received notable academic awards and other honors, as well as other recognitions from their peers in the form of memberships in academic societies, grant panels, and journal editorial boards, as noted on their accompanying CVs (see Appendix D).

2 Evaluate the impact of the Center on engagement metrics

2.1 Number of affiliated faculty, by college and by sector area to gauge depth of community in strategic emphasis areas called out in the institute strategy

Affiliated faculty: 33

<table>
<thead>
<tr>
<th>School of Medicine: 24*</th>
<th>College of Arts &amp; Sciences: 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pharmacology &amp; Experimental Therapeutics</td>
<td>4</td>
</tr>
<tr>
<td>Neurology</td>
<td>1</td>
</tr>
<tr>
<td>Biochemistry</td>
<td>7</td>
</tr>
<tr>
<td>Biomedical Engineering</td>
<td>4</td>
</tr>
<tr>
<td>Physiology &amp; Biophysics</td>
<td>1</td>
</tr>
</tbody>
</table>

*Some faculty have dual appointments
2.2 Number of affiliated industry practitioners, by sector area: n/a (but two biotechnology partners, Merck, Johnson & Johnson)

2.3 Number of affiliated alums: 12

Reflections from former students:

Isabella Turcinovic – Undergraduate (2018-2021)
The CNSB and the Emili group were central to my development as a scientist and student. Through the lab, I was able to more deeply develop my skill set at the lab bench and my ability to design and execute a comprehensive experimental workflow to answer research questions, giving me a more comprehensive view of scientific research. As a result, I have become a more confident, capable, and independent researcher.

I joined the Emili group in my first year of undergrad hoping to better understand proteomics, which had previously piqued my interest. Through the projects I was involved in over the next four years, I developed a great appreciation for methods development, microscopy, and the large amounts of data afforded through the “-omics,” which have gone on to shape the kinds of scientific goals I have for my future. I am deeply grateful to all of the members of the lab for their guidance and encouragement over the course of my undergrad, as I am confident the skills and knowledge I have gained through my time at the Emili group will continue to guide my scientific inquiries and enrich my appreciation for research.

David Guarin – Undergraduate (2020-2021)
I started at CNSB in my last semester as an undergraduate at Boston University. Before joining the lab, I had no previous wet lab experience outside of coursework. Therefore, jumping into proteomics research presented a significant challenge. Thankfully the PI, senior scientists, and graduate students made my transition seamless. Their teaching, patience, and guidance quickly shaped me into a capable and rigorous scientist.

In the lab, I was in charge of developing and optimizing a Mass Spectrometry-based Cellular Thermal Shift Assay (MS-CETSA), primarily in collaboration with Pelago Biosciences and the Porco group. I had to design experiments based on primary literature, troubleshoot when things didn’t work, and update collaborators on our progress. While my time at CNSB was relatively short, the mentorship I received, and the skills and friendships I gained, have equipped me to become a successful scientist in my next lab experience and beyond. After CNSB, I will be joining the Harvard Research Scholar Initiative as a student in the inaugural cohort for the Program in Neuroscience track (PiNBAC).

Devansh Bansal – Summer RISE student (2021)
I am Devansh Bansal, a high school student at Bellarmine College Preparatory in San Jose, California. I am passionate about STEM and biology, aspire to go into health services, and currently participate in speech and debate, quiz bowl, a cappella singing, and local community volunteering. During Boston University’s RISE 2021 summer program, I worked with Ahmed Youssef to develop an interactive web tool for computational protein network analysis. The tool uses code in R to compare any number of networks and compute analyses like network overlap, differential connectivity of genes, and biological pathway enrichment. By testing this tool on various sets of real-world networks, we confirmed the capability of this tool to conduct valuable and potent analysis. Through this project and with CNSB, I learned how crucial interactomics and protein network analysis are for molecular biology as a whole and the isolation of disease-causers and possible medicinal drugs. The lab was very helpful in guiding me through the project development, and I am very grateful for having had this opportunity.

2.4 Number of currently affiliated students: 12

2.5 Number of conferences (with attendance metrics):
   - Conferences: 1 (first annual conference, October 2019, pre-COVID-19)
   - Attendance: 86 registered in person, 119 via streaming

2.6 Number of panel discussions and other virtual events (with attendance metrics)
   n/a

2.7 Number of executive programs (with attendance metrics)
   n/a

3 Evaluate the Center’s future as a research center of excellence

3.1 What significant strategic opportunities for University prominence does the Center provide?

Human health and disease are governed at the subcellular levels by the action of dynamic molecular networks, whose elucidation is both important and challenging, and therefore likely to remain a major focus for the molecular biology, developmental biology, pathobiology
and synthetic biology research communities for decades to come. As a result, BU and other leading academic institutions have a need to continue investing in high-performance experimental research and training platforms, to advance fundamental knowledge creation and its transformation into innovative medicines and other biotechnology products.

3.2 What is the Center’s defining vision, how was it developed and how does it align with the strategic plan of its cognate departments and schools or colleges and/or of the University?

The mission of the CNSB is to create and deploy mass spectrometry-based approaches to study the physical and functional interactions of cellular biomolecules crucial to health and disease. One of the best predictors of a protein’s knockout phenotype—whether in yeast, worm or human—is the function of the interacting protein partners within a cell. CNSB aims to map the biological networks that underlie normal biological development, cellular function, and the emergence of pathophysiological alterations; this information is fundamental to a deeper mechanistic understanding of core cellular processes and their causal links to clinical disorders.

CNSB’s vision is to be a premier inter-disciplinary research center that transforms the field of systems biology through research and innovation in functional proteomics technology, multi-lab team building, leadership, and training. Our research program aims to provide: (i) compendiums of high-confidence protein interaction networks with direct relevance to human biology, health, and potentially clinical care; (ii) valuable technologies, computational tools, and public data resources for biomedical researchers at BU and beyond; and (iii) an outstanding training environment that produces next generation leaders in precision proteomics, bioinformatic data sciences, and systems/ network biology.

CNSB researchers have shown that cellular ‘interactomes’ are highly modular and dynamic, consisting of distinct protein assemblies that participate in different pathways in distinct cell types in response to a multicellular organism’s changing physiological needs and developmental cues. The ability to map these networks reliably and comprehensively still forms the operational model and vision of the CNSB, and it is equally relevant today as when its Charter was first drafted four years ago. While the pandemic has impacted the operations of virtually all academic units, it has also brought into sharp focus the need for proteomics research centers to be nimble, collaborative, and inter-disciplinary. The CNSB has shown it has the proven technical capabilities, infrastructure capacity, and collaborative mindset to address emerging biomedical research questions and the fundamental molecular mechanisms leading to widespread disease. By contributing to a vibrant, diverse, and inclusive research and educational community that seeks to advance fundamental understanding of human biology, the CNSB also supports multiple enduring goals of the University’s strategic plan.

3.3 What other University centers are most closely related and in what ways do these research units compete and/or collaborate?

CNSB has established close and productive collaborations, leading to co-publications, joint grant submissions and shared training, with multiple other centers at BU. Most prominently, these include:

NEIDL – Boston University’s National Emerging Infectious Diseases Laboratories – even prior to COVID-19, CNSB had been working closely with microbiologists, virologists, and other faculty and scientists at the NEIDL, such as Elke Mühlberger, Mohsan Saeed, John Connor, Rob Davey, and Florian Douam, to leverage its extraordinary biocontainment capabilities and the results of ongoing small-molecule drug discovery efforts in an effort to discover potent targets to block the SARS-CoV-2. These interactions have been fruitful and, in addition to multiple co-publications, have resulted in a major recent RM1 team grant submission, co-led by CNSB Director Emili together with Prof. Mühlberger at the NEIDL, to form a National Center for Viral Interactomics. The CNSB is also supporting efforts by researchers at the NEIDL to discover which host cell proteins are cleaved by proteases encoded by SARS-CoV-2 and other pathogenic viruses as they hijack a human cell.

CReM – Boston University’s Center for Regenerative Medicine – a joint initiative of the BU School of Medicine and Boston Medical Center, CReM is one of the nation’s few centers focused on differentiating patient-derived stem cells into lung cell (and other tissue types) for patient-centric disease modeling. CNSB has been working closely with CReM researchers over the past four years to gain mechanistic insight into the pathogenesis of different lung diseases, including the effects of oncogenic mutations leading to lung adenocarcinoma in an ongoing project (entering third year) funded by the biotechnology investment arm of Johnson and Johnson. These projects have led to multiple high impact papers, including one most recently in Cell Stem Cell.

BDC – Boston University’s Biological Design Center – research is focused on examining cellular processes to unlock the underlying design logic of biological systems, then leveraging these building blocks to create designer cells, organisms, and functions not found in nature
for applications in biotechnology and medicine. CNSB has had especially productive interactions with the BDC Director and other faculty, resulting in multiple joint projects and grant submissions together. For example, the CNSB is working closely with BDC faculty to explore the network biology of engineered human cell models of disease, such as hypertrophic cardiomyopathy and immune cell exhaustion, to define clinically actionable targets.

CBMS – The Boston University Center for Biomedical Mass Spectrometry – an internationally recognized leader in the field, CBMS develops and applies advanced MS and LC/MS instrumentation and methods focused on the areas of glycobiology and the definition of novel and/or complex post-translational modifications of proteins. As a natural partner, CNSB and CBMS share a number of personnel, including both administrative and computational staff, as well as faculty members, including Prof. Mark McComb, who is intimately involved in the maintenance of both instrumentation platforms.

4 Evaluate the impact of the Center on the University’s larger mission in education:

4.1 What is the Center’s impact on its cognate departments and schools or colleges (list specific courses, seminars, symposia offered in the last 5 years)?

The CNSB supports broad and appropriate use of proteomic technologies, bioinformatic tools, and systems biology concepts to solve critical questions in biomedicine; thus, we deploy a variety of educational mechanisms to familiarize, train and enable undergraduates and junior investigators to relate to their own academic needs, research questions and career goals. For local trainees, CNSB affiliated faculty have taught various components of the graduate courses “Mass Spectrometry, Proteomics and Functional Genomics”, “Introduction to Graduate Biochemistry” and “Mass-Spectrometry Analysis”, attended by graduate students, postdoctoral fellows, and even junior faculty, along with personnel from collaborating laboratories and local industries. Annually, about 30-40 students take the courses for credit, and others come to gain information useful for their current research and to explore new concepts. With the initial onset of the COVID-19 pandemic, we adopted virtual curricula and transitioned from classroom to online teaching. Last year’s virtual classrooms have shown that we can effectively communicate advanced teaching concepts and material to students outside our campus, supplementing traditional course material with direct web links to journals, databases, software tools, relevant teaching videos, etc. Most participants in the courses adapted well to this teaching style, and we received tremendous positive feedback, demonstrating that these means of teaching and dissemination are effective and can potentially reach a large audience. In the end, our virtual classrooms proved to be highly effective for the purposes of teaching/training and dissemination.

4.2 How does the Center influence education at the undergraduate and graduate levels?

We have a proven track record in graduate mentorship and undergraduate training. CNSB provides a unique research environment, exposing trainees to advanced proteomic techniques, computational concepts, and other technologies. While most of our graduates remain in academia, some opt for biotech careers. By establishing an open, well-rounded relationship with each trainee, and guiding self-motivated scientific inquiry towards independent scholarship, the Center cultivates independence, leadership, scientific excellence and teamwork. Trainees are mandated to address important biomedical research questions with the goal of long-term impact, not short-term results. In addition to honing experimental skills and bioinformatic capabilities, trainees learn to exercise robust critical judgement. Trainees also draft and review manuscripts, and they present and defend their work in formal group discussions. The CNSB mentoring style adapts to individual trainees’ backgrounds, strengths and shortcomings, aiming for balance through regular coaching, critical feedback and encouragement to ensure they grow intellectually while striving for research excellence. Since many come from abroad, we work to overcome language and cultural barriers. All trainees benefit from access to exceptional resources, including in-house programmers who provide support for addressing challenging data analysis problems. To ensure consistent quality and scholarly development, Center staff plan numerous opportunities to meet with and counsel trainees to provide ongoing project direction as they strive towards scientific independence. Trainees have individualized projects with carefully scrutinized work-plans that are monitored relative to academic development checkpoints.

Boston is home to a large and growing number of biotech companies underpinning a transformational shift in the pharmaceuticals industry towards biological macromolecules and antibody-based blood products (i.e., “biologics”). Thus, there is a high demand for Center graduates who are exceptionally skilled in LC/MS-enabled research skills, able to bridge knowledge gaps between complementary fields and effectively apply their research expertise to meet the needs of industrial/biotech research enterprise. Notably, CNSB trainees acquire research expertise in the characterization of complex protein systems, complemented by experience with high efficiency separations, sample handling, cell culture and knowledge of biological systems. Trainees acquire research expertise in the characterization of biomolecules, biomolecular interactions, and relevant biochemical systems. Trainees also gain experience in the development of LC/MS-based methods for quantitative and qualitative analysis of these species, which are of rapidly increasing importance to industry. They acquire expertise in design and/or modification of LC/MS and associated instrumentation, and development of analytical techniques that employ chemical reactions or modifications. Trainees exit with superior technical competence and professional skills, which will make them highly sought after in any of the growing number of industries for which LC/MS-enabled research is providing a foundation. By fostering highly skilled trainees, we enable
productive long-term careers and wider knowledge dissemination throughout industry and biomedicine as well as academia. Beyond the sizeable number of trainees for diverse departments currently in or rotating with CNSB core faculty, the Center influences education at the undergraduate and graduate levels more generally through our establishment and maintenance of a vigorous online presence: website outreach, including animated scientific videos on YouTube and daily/weekly social media via a dedicated and vocal Twitter channel, and a comprehensive set of Center website/project web portals to disseminate information about our research and training activities, and to enable widespread access to the unique resources the Center creates. Twitter feeds provide a versatile and rapid two-way communication of information and real-time metric of our on-going research activities, sharing news of awards, publications, student and postdoc projects, and other announcements, such as acquisition of new instruments that expand our capabilities. The website showcases the Center’s unique technical capabilities, research objectives, and mentoring activities, while providing overviews suited for the general public about the projects and technologies being developed. Our individual affiliated laboratories already have a strong web presence to promote our research and disseminate information. In addition, we successfully engage with the community via social media as a means to rapidly provide outreach and receive feedback on our research efforts. These platforms allow effective communication of our research goals, staff, findings, course material, laboratory protocols, and software tools, with links to publications, conference proceedings and data sets. We also advertise workshops, symposia and other training opportunities.

V. ASSESSMENT OF RESOURCES AND ADMINISTRATIVE INFRASTRUCTURE AND SUPPORT

1. Organizational chart and faculty and staff members

CNSB Organizational Chart

CNSB Staff:

Andrew Emili, PhD, Director, Professor Biochemistry & Biology. Professor Emili is an internationally recognized pioneer in mass spectrometry-based functional proteomics who has led numerous large-scale biology, team science and technology development projects, together with a diverse array of collaborators. Prof. Emili coordinates with and harness the Center’s network of affiliated faculty to generate and disseminate high impact research findings that advance basic and applied biomedicine.

Mark McComb, PhD, Research Associate Professor, Biochemistry. Professor McComb contributes to the management of LCMS and related proteomics platforms and bioinformatics infrastructure within the CNSB Medical Campus and Charles River Campus laboratories. He takes part in methods development and collaborative research in all aspects of CNSB MS related research and conducts training and mentoring within the laboratory and the classroom.
**Ryan Hekman**, Mass Spectrometer Specialist. Ryan supports all the instrumentation needs for the lab members by maintaining the mass spectrometers and making sure the lab has enough supplies. He also provides expert advice and training in proteomics and data analysis.

**Carl White**, Analyst. Carl performs feasibility analyses and develops data analysis software for PRISM, a novel approach to protein identification. He also assesses protein cross-linking methodologies and provides computational support for other projects.

**Sadhna Phanse**, Analyst. Sadhna performs drug target identification analysis of thermal shift assay/ligand stabilization CETSA assay samples; develops a web-based platform for analysis of chemical proteomics samples; performs protein-protein interaction scoring and analysis; and develops and manages project-based websites for publication.

**Christian Heckendorf**, Bioinformatics Analyst. Christian assists lab members with analyses and develops software to facilitate running standardized analysis workflows. He also helps manage the lab's data storage and compute infrastructure. In addition, he is building a data warehouse to link experimental CETSA-MS data with known protein–drug interactions and associated information to streamline the discovery process.

**Indranil Paul**, PhD, Research/Staff Scientist. Indranil is currently leading several multi-scale proteomics projects within the Center. Of note was the development of a workflow for concurrently acquiring data for up to 12 -omics modalities from the same samples for a comprehensive systems characterization of biological processes with potential translational impact. Indranil is involved in developing streamlined pipelines for incorporating latest developments and best practices in proteomics. He also provides his expert consultations and experimental support on mass spectrometry and other proteomic tools to academic and industry collaborators, within and beyond Boston University.

**Avik Basu**, PhD, Research Scientist. Avik works on development and optimization of protein–protein interaction techniques using the high throughput mass-spectrometry platform at CNSB. Parallel to his own projects on neuro-proteomics, he gives advice and both coordinates and analyses samples from various collaborators, ranging from basic cell biology, development, virology, and neuroscience to cancer-related projects. Avik also manages CNSB's biosafety and chemical safety protocols including smooth operation of the animal tissue culture facility, and he oversees the supply/ordering and maintenance of the general lab.

**Noah Lampl**, Research Assistant. Noah is the research assistant to Dr. Weiwei Lin. Noah assists with processing and analyzing contributor samples, predominantly in the proteomic workflow. He is finishing analysis for an experiment focused on studying long-term stress responses in rats by looking at proteins in aortic tissue, and he is examining sensory neurons of maturing mice to characterize proteins involved in neuronal development.

**Jaymie Zapata**, MSW. Jaymie is the administrative coordinator for the Center, managing the purchase of supplies and equipment, service contracts, and heading the Center's social media efforts.

**CNSB Affiliated Faculty:**
Members have priority access to facility resources, and enhanced project coordination. Our current affiliated faculty are:

- **Peter Ash**, PhD, Research Assistant Professor, Pharmacology & Experimental Therapeutics
- **Aaron Beeler**, PhD Associate Professor, Biomedical Engineering; Co-PI, Center for Molecular Discovery
- **Markus Bosmann**, MD, Associate Professor, Medicine, Pathology & Laboratory Medicine
- **Cynthia Bradham**, PhD, Associate Professor, Biology
- **Esther Bullitt**, PhD, Associate Professor, Physiology & Biophysics
- **Daniel Cifuentes**, PhD, Assistant Professor, Biochemistry
- **Mark Crovella (CS)**, PhD, Professor and former Chair in the Department of Computer Science
- **Alberto Cruz-Martin**, PhD, Assistant Professor, Biology
- **Robert Davey**, PhD, Professor, Microbiology
- **Sarah Davies**, PhD, Assistant Professor, Biology
- **Gerald Denis**, PhD, Associate Professor, Pharmacology and Medicine; Co-Director, BU-BMC Cancer Center Education
- **Rachel Fears**, PhD, Professor, Microbiology
- **David Harris**, MD/PhD, Professor and Chair of Biochemistry
- **Angela Ho**, PhD, Associate Professor, Biology
- **Ahmad (Mo) Khalil**, PhD, Associate Professor, Biomedical Engineering
- **Darrell Kotton**, MD/PhD, David C. Seldin Professor, Medicine, Pathology and Laboratory Medicine; founding Director, Center for Regenerative Medicine
- **Kim McCall**, PhD, Chair and Professor of Biology
- **Stefano Monti**, PhD, Associate Professor, Medicine and Biostatistics
- **Elke Mühlberger**, PhD, Associate Professor, Microbiology; Investigator, NEIDL
- **Valentina Perissi**, PhD, Associate Professor, Biochemistry; Co-PI and Director, Boston Nutrition Obesity Research Center
- **John Porco**, PhD, Director, Center for Molecular Discovery; Co-Director (w/ A. Emili) of the BU Target Discovery Laboratory
- **Wendy Qiu**, MD, PhD, Professor, Psychiatry; Professor, Pharmacology & Experimental Therapeutics
2. Is the Center’s critical mass associated with a single department or college?

The Center’s critical mass is located within the Department of Biochemistry on the Medical Campus, but the affiliate network extends extensively to other academic units across both campuses.

3. What is the income, the sources of funding, and annual expenditures? (Provide detailed budget information for the past year and a total budget for the past five years, including grants, contracts, gifts and discretionary funds.)

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4. What annual support is provided by the University for staffing, operating expenses, and infrastructure, including discretionary and unrestricted budgets?

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5. What external support has the Center been awarded over the last five years? Apart from research support also include any endowment funds, training grants, fellowships, etc. secured at least in part through the effort of the Center.

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6. Provide a description of the progress made through the activities of the Center that are connected to the externally funded projects.

CNSB has rapidly expanded, matured, and made headway towards its core mandate of building a robust infrastructure platform, located primarily on the BU Medical Campus but now encompassing a new Target Discovery Laboratory on the Charles River Campus, advancing a highly collaborative trans-disciplinary scientific program, and (iii) securing substantive external funding.

7. Describe how the Center has contributed to supporting the University’s costs for research, including student fellowships, equipment purchases and administrative support over the past five years.

In its first 4 years, CNSB has brought in over $2 M in indirect costs to the University from the NIH and other funding bodies. CNSB also successfully competed for funding in 2020 from the NIH (1S10OD026807; HEI grant PI: Emili) for an “Ultra-High Precision Mass Spectrometer”, supporting the acquisition of high-end instrumentation to identify the molecular targets of bioactive compounds of faculty in the departments of Chemistry, Biology, Bioengineering and other affiliated faculty at BU. CNSB Director Emili was also a co-applicant on five successful PhD/Postdoc training grants.

8. What resources are needed to achieve the objectives of the Center’s strategic plan and what is the evidence that supports the assertion that these objectives will be met?

Sustaining CNSB’s research capacity, particularly the challenges of servicing its instrumentation and growing its footprint and recognition beyond the BU community, depend on strategic support from the BU senior administration. Stable funding of CNSB’s LC/MS facilities and core technical and administrative team enables the CNSB leadership, and its affiliates, staff and trainees, to compete for and secure federal investments by engaging in transformative research that will attract larger grants, growing our national prominence, and potentially earning international accolades.

9. Describe the Center’s current and future facilities and space needs.

While a distributed community, CNSB supports its collaborative efforts via defined facilities on the Charles River and Medical Campuses. The main laboratory space is located in the Conte/K-Building on the Medical Campus, while a new ancillary laboratory was recently established in the Life Science and Engineering Building on the Charles River campus. Each laboratory has sufficient space to host 8–12 students, post-doctoral fellows, and other research members. Both laboratories host high-performance LC/MS instrumentation, and associated workstations for data processing, and high-speed Internet for data transfer to dedicated data processing and storage arrays.
The main laboratory on the Medical Campus has a dedicated cell culture room with two biosafety cabinets, dedicated laboratory space for sample processing and a dedicated mass spectrometry room with three high performance LC/MS systems: one QExactive-HF nano LCMS system and two new Orbitrap Exploris 480 nano-LC/MS systems. Current systems run 24 hours per day, seven days per week, with user access in excess of 90% of instrument time. Our standard workflows incorporate isobaric tagging with off-line fractionation, allowing us to process hundreds of individual project experiments per year. Adjacent to the laboratory is a dedicated office area for computational staff with seating for eight, and a conference room suitable for multi-lab group meetings. The laboratory is also equipped with -80°C and -20°C freezers, refrigerators, incubators, and suitable benchtop equipment to conduct systems biology research, while throughput is supported by two automated off-line HPLC systems and a Kingfisher sample-processing robot. Laboratory space on the Medical Campus is currently at full capacity.

The Charles River laboratory was recently setup and we are still expanding into this space. The core component is a state-of-the-art ThermoFisher Eclipse nano-LC/MS system funded by the NIH (HEI grant) primarily dedicated to drug-target discovery research projects. As with our Exploris instruments, the Eclipse is outfitted with a FAIMS PRO (High-Field Asymmetric-Waveform Ion Mobility MS) interface that acts as an ion filter to remove isobaric interferences to improve quantification and robustness, thus reducing cleaning cycles. The laboratory is equipped for cell culture and includes a biosafety cabinet and has -80°C and -20°C freezers, refrigerators, and sufficient benchtop equipment including a thermal cycler and off-line HPLC. Laboratory space on the Charles River campus is sufficient for now and the near future.

10. Describe the Center’s access to technology and libraries as well as other research and learning resources.

The CNSB takes full advantage of the numerous resources offered through Boston University Information Technology and Boston University Libraries. This infrastructure also provides a means of collaboration, data exchange, and sharing of educational, training and teaching material.

BU-IT Support and assist with maintaining a high-speed one gigabit and 10 gigabyte (GB) network and assist CNSB staff with the management of multiple laboratory PCs and high-performance computer servers and workstations used for data processing and data storage.

Members and collaborators of the CNSB have access to the Shared Computing Cluster (SCC): computing infrastructure for use in analyzing large and complex proteomics and systems biology data sets.

In addition, we have support from the University for hosting information on our websites including news items, access to staff and group members, means of collaboration, methods and protocols, and publications, as well as training and teaching material that we disseminate to the community.

VI. PLAN FOR IMPROVEMENT

Unlike many of the existing BU research centers, that had a sizeable existing faculty base at conception, the CNSB was created from scratch. In this context, CNSB’s rapid growth and development of scientific connections over the past four years, during a major pandemic, are all the more remarkable. Our plan for improvements emphasizes continued support for the platform that we have built and how we aim to further integrate it with other major scientific initiatives at BU, particularly in the areas of Data Science. Below, we address potential criticisms, some stemming from factors beyond our control, where the university can potentially help.

1. List core objectives and priorities as part of a plan for improvement over the next five years; clearly identify the sequence of actions to be taken for each.

As the Center approaches the last year of its first term and looks back to what worked well and what might have proceeded better, some of it under our control and some beyond our influence, CNSB faces the next five years with a clear and optimistic vision that, despite the persistence of the pandemic, we expect to grow and advance our Center’s inter-disciplinary goals, scholarly profile and academic impact by addressing four concrete scientific goals:

First, CNSB will continue to ramp up its pioneering efforts with affiliated BU faculty in chemo-proteomics, combining ligand affinity purification with metabolic modeling, medicinal chemistry, and structural proteomics, to speed the discovery and characterization of bioactive compounds for human protein targets with the ultimate aim of developing effective therapeutics.

Second, CNSB will implement its current research capabilities—which benefit from recent enhancements to sample throughput—to apply quantitative phosphoproteomics and interactomic profiling to large numbers of in vitro (organoid) and in vivo (animal) models of disease.
These include investigating (i) the dysregulated metabolic milieu of the tumor microenvironment, (ii) the emergence of fibrosis associated with cardiac disease progression, (iii) neuron-glia-astrocyte crosstalk during neurodegeneration, and (iv) the impact of adipocytes, obesity, metabolic syndrome and diabetes on cancer progression.

Third, CNSB aims to build out and leverage our partnerships in the new Faculty of Computing and Data Sciences to enable the deployment of innovative machine learning and network inference algorithms to deconvolute causal regulatory relationships through the integration of metabolomic, phosphoproteomic, genomic and interactomic datasets to discover unifying biophysical principles governing cell states, cellular heterogeneity, and multi-cellular communities.

Fourth, working with affiliated faculty in the Chemistry, Bioengineering, and Neurophotronics, CNSB aims to advance groundbreaking imaging technology to support the nascent field of single-cell spatial proteomics.

The ambitious objectives listed above are aspirational, and despite our best efforts, some of these efforts are currently unfunded, high risk, and may eventually fail. Yet collectively, we are confident CNSB will advance on multiple fronts, and that we can successfully navigate hurdles and re-prioritize goals according to progress or roadblocks.

2. Consider where the academic discipline is likely to be headed in the next five years and indicate how the Center will position itself in this evolving context.

Despite the role of the Center in advancing proteomics on multiple fronts, the complexity of interdisciplinary research and sustaining technology platforms at the leading edge create challenges that must be overcome:

1. Biological – Many of the molecular interactions that govern biological processes are transient and weak (i.e., kD in mM range) with coefficients that are highly sensitive to minute variations in the chemical environment of the cell. Biomolecular complexes are therefore often exceptionally difficult to characterize, with most technologies providing at best a fragmented picture. Yet unbiased characterizations are crucial to understanding how biological systems operate at the molecular level.

2. Technical – The development of new methods that provide a complete picture of biomolecular complexation is a major, longstanding objective of bioanalytical research. While mass spectrometry-based functional proteomic workflows are generally sensitive and robust, improvements in performance and throughput are urgently needed to meet emerging expectations. Performing reliable functional proteomics studies in large numbers of small amounts of biological materials, potentially even single cells, will require continuous technical innovations.

3. AI – As in other spheres, systems biology is being driven by advances in data sciences. Directing some of the ample faculty hiring resources and emergent academic power of the new Faculty in Computing and Data Sciences towards biomedical research in general, and the CNSB more specifically, would be strategically highly impactful in allowing the Center to mediate a synergistic triangulation between BUSM, CAS and CDS. Neglecting this window of opportunity will have negative consequences for the competitiveness of the biomedical research enterprise at BU.

4. Organizational power – While the research mandate of CNSB is well defined, it holds modest financial sway and limited influence in terms of faculty recruitment and retention as compared to established organization units such as Departments at BU. This tension hobbles its long-term impact on the operations of the University outside of addressing research problems of the day. Nurturing, gauging, and rewarding the success of interdisciplinary research by extra-departmental centers needs to go beyond easily quantifiable metrics. As biomedical research becomes increasingly inter-disciplinary, it is constrained by traditional academic structures.

5. Retention – Boston is a scientific Mecca, and the exceptionally high concentration of biotechnology and big pharma offers pros and cons to the scientific enterprise at BU. Most notably, highly skilled staff have been poached by the offer of much higher paying positions in industry, which hampers our research and training capacity. As the pandemic rattles people’s career plans, the need to reward staff through improved compensation, awarding academic titles, and by other non-monetary mechanisms will prove key to stability, productivity and growth.

3. Consider what opportunities exist to extend existing strengths and briefly discuss the major obstacles.

The current pandemic highlights the need for rapid, flexible deployment of functional proteomics technologies, particularly interactome mapping and quantitative phospho/proteomic profiling, to gain clinically actionable mechanistic comprehension of disease mechanisms. Since its emergence and rapid spread, the novel coronavirus has put extraordinary strain on the biomedical research community, but many scientists, including members of our Center, have come together with astonishing speed, racing to generate insights in an unprecedented
manner. Notably, faced with a problem that requires expertise across disciplines, we assembled a group of over 40 researchers to map the viral–host interface landscape of SARS-CoV-2 in engineered human cells, describing the temporal dynamics of protein phosphorylation occurring in infected host cells, and predicting new targets and testing compounds for antiviral activity within a matter of months. Because of the wide sharing of expertise, methods and tools, research usually taking years to complete is now being completed in months or even weeks. Considering the extraordinary pace of scientific progress achieved over the past year—at least in the virology space during the height of the pandemic—CNSB leadership believes that while such sustained efforts are hard to maintain for long periods, a key lesson is the need to preserve or inject flexible monetary, infrastructure, and human capital to allow the Center to pivot towards unforeseen future challenges and opportunities. While we recognize resources are finite, and potentially even more so in the years ahead, the CNSB will thrive when supported to conduct interdisciplinary research and cross-institutional collaborations in a fluid and adaptive manner.

While our infrastructure is currently state-of-the-art, now that the startup funds are gone, establishing mechanisms to support the eventual renewal of CNSB LC/MS platforms four to five years down the road is an important eventual task facing the Director and the administration.

4. Explain the internal improvements that are possible through reallocation of existing resources; explain improvements that can only be addressed through additional resources.

Targeted faculty recruitment in Computing and Data Sciences has the potential to create very productive long-term synergies between CNSB and collaborating biomedical researchers across both the BUSM and CRC campuses, resulting in a windfall for all. Substantive federal funding opportunities in this space are rapidly arising, but the focus at BU has been on designing and implementing a robust undergraduate and graduate training experience in more traditional CS domains. BU risks missing the competitive window for tailoring innovative AI solutions to the biomedical data currently generated at BU as more nimble institutional competitors sprint to seize the prime scientific and funding opportunities.

5. What are the three principal arguments that would support the notion that renewing the Center’s charter for another five-year period should be a strategic priority for the University?

Universities compete for the best students, top academic talent, and access to federal and alternate funding. Competition in the post-COVID-19 higher education research environment is likely to be even fiercer, and successful institutions will support interdisciplinary educational, training, and research platforms that prepare society for the complex biomedical challenges our aging and increasingly diverse population faces. Over its first four years as a highly productive, collaborative, nimble and impactful research center, CNSB has proven its key role as a financially sustainable scientific leader and value creator. Based upon our track record of collaboration, training and dissemination and substantial growth from conception to high performance day-to-day facility, the main arguments to renew the Center’s charter for a second five-year period are multiple and compelling—namely, CNSB will:

(i) Continue our vision to be a premier inter-disciplinary research center transforming the field of systems biology through research and innovation in functional proteomics and interactomics, multi-lab team building, scientific leadership, and attentive training.

(ii) Develop, deploy and disseminate innovative experimental and computational capabilities that advance the field of network systems biology while empowering the research competitiveness of numerous affiliated BU faculty strategically in the biomedical domain while achieving self-sustained funding in the near future;

(iii) Mentor trainees in high demand academic fields in academia and biotechnology and enhance President Brown’s directive for One BU and societal impact through groundbreaking research spanning both campuses that raises BU’s profile on the local and national scientific world stage, and corresponding academic rankings.

We close by emphasizing that CNSB fits perfectly within BU’s new strategic plan by contributing to a vibrant, diverse and inclusive research community that is supported by world-class inter-disciplinary scientific capabilities to advance fundamental understanding of human biology and health.
The Center for Network Systems Biology at Boston University supports ambitious research initiatives to map protein interaction networks in different biomedical contexts. CNSB provides essential interdisciplinary knowledge as well as the technical prowess to get to the heart of network systems biology. With collaborative research programs based across both Boston University campuses – BU Medical Center and Charles River – the CNSB serves as a leading scientific hub from which to chart the dynamic molecular networks critical to human health and disease.

Andrew Emili, PhD, Director of the CNSB and Professor of Biochemistry, Biology, Computing and Data Sciences.

The Center for Network Systems Biology of Boston University is located in the Silvio Conte Building (K-320) of the Medical Campus at 71 E. Concord St., Boston, MA 02118; and on the Charles River Campus in the Life Science & Engineering Building (LSEB – 712), 24 Cummington Mall, Boston, MA 02215.

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