PROGRESS TO DATE: STATUS OF ND-ACES METRICS

TABLE 1. CCBSE MATERIALS DESIGN AT BIOINTERFACES PILLAR OUTPUT METRICS

CCBSE: Materials Design at Biointerfaces Pillar	Year 1 July 1, 2020-June 30, 2021	Year 2 July 1, 2021-June 30, 2022	Year 3 July 1, 2022-June 30, 2023	Year 4 July 1, 2023-June 30, 2024	Year 5 July 1, 2024-June 30, 2025
Objective 1.1a: Design and optimize nanoclay scaffolds (Activity 1: Prepare nanoclay scaffolds with amino acids for cancer cell growth)	Prepare 3 different biocompatible scaffolds Y1 Annual Report: On track to complete Y1 ACTUAL: Prepared 3 nanoclay scaffolds. These scaffolds will be delivered to the Cellular Team in Y2.	Develop 2 nanoclay scaffolds incorporating the amino acids and evaluate additional one hard scaffold Y2 Annual Report: All three Y1 hard scaffolds were delivered to the Cellular Team in September 2021. On track to deliver Y2 scaffolds and evaluation. Y2 ACTUAL: Evaluation of the Y2 scaffolds is in progress.	Select one optimal scaffold (critical) Y3 Annual Report: Nanoclay scaffolds with two amino acid modifiers prepared and compared.	Prepare enough scaffolds for the other Pillars and for Materials Design Pillar Goal 3	Prepare enough scaffolds for the other Pillars and for Materials Design Pillar Goal 3
Objective 1.1a: (Activity 2: Assist non-RU campuses involved in Activity 1 with compliance protocols) *[Change in metric approved by NSF on 7/28/21]*	Assist with the initiation of conversations between non-RU faculty and RU campuses for the administration of necessary compliance protocols (IBC, MTAs) Y1 Annual Report: N/A Y1 ACTUAL: Change under review by NSF	Ensure that all necessary compliance protocols are in place at the non-RU campuses Y2 Annual Report: Per NSF policy, IBC protocols are not required of non-RU CCBSE researchers. See PROSPER P&C regarding workshops delivered to CCBSE researchers in Y2. CCBSE leads will develop a blanket NDA and MTA for CCBSE by the end of Y2. Y2 ACTUAL: Completed	Ensure that all necessary compliance protocols (IBC, MTAs) are in place at all campuses Y3 Annual Report: All compliance documents are in place.	Ensure that all necessary compliance protocols (IBC, MTAs) are in place at all campuses	Ensure that all necessary compliance protocols (IBC, MTAs) are in place at all campuses

Objective 1.1b: Characterize the scaffolds and demonstrate cancer cell growth (Activity 1: Characterize the scaffolds and culture of breast and prostate cancer cells)	Complete characterizations on the scaffolds prepared in 1.1a. Demonstrate growth of MCF7 and PC3a cells Y1 Annual Report: On track to complete Y1 ACTUAL: Completed characterizations on the 3 nanoclay scaffolds from 1.1a; growth of MCF7 and PC3a cells was demonstrated.	Demonstrate growth of MDA-MB-231 and PC3 cells and compare with MCF7 and PC3a cells Y2 Annual Report: Scaffold activity with 4 types of cells completed on one hard scaffold and initiated on second hard scaffold. Y2 ACTUAL: Cell growth studies on the second scaffolds are in progress.	Demonstrate tumoroid formation (critical) Y3 Annual Report: Tumoroid formation demonstrated.	Time evaluation of tumor growth on optimized scaffolds	The tumors on the scaffold are genetically and morphologically similar
Objective 1.2a: Design and optimize soft polymeric scaffolds (Activity 1: Prepare soft scaffolds from Chi, Alg, and PgA, characterize the scaffolds)	Prepare 3 different biocompatible scaffolds Y1 Annual Report: On track to complete Y1 ACTUAL: Prepared 3 scaffolds. These scaffolds were delivered to the Cellular Team in Y1.	Prepare 3 different biocompatible scaffolds Y2 Annual Report: Y1 scaffolds were rejected by the Cellular Systems team due to low pH values. Four new soft scaffolds have been developed and delivered to the Cellular Systems team. Y2 ACTUAL: One soft scaffold supports cell growth for a limited time. Studies are in progress.	Select 1 optimal scaffold (critical) Y3 Annual Report: We are still optimizing the soft scaffolds with modified composition. Currently, the scaffolds support cancer cell growth for 8 days.	Prepare enough scaffolds for the other Pillars and for Materials Design Pillar Goal 3 (nanomaterials testing)	Prepare enough scaffolds for the other Pillars and for Materials Design Pillar Goal 3
Objective 1.2a: (Activity 2: Assist non-RU campuses involved in Activity 1 with compliance protocols) *[Change in metric approved by NSF on 7/28/21]*	Assist with the initiation of conversations between non-RU faculty and RU campuses for the administration of necessary compliance protocols (IBC, MTAs) Y1 Annual Report: N/A Y1 ACTUAL: Change under review by NSF	Ensure that all necessary compliance protocols are in place at the non-RU campuses Y2 Annual Report: Per NSF policy, IBC protocols are not required of non-RU CCBSE researchers. See PROSPER P&C regarding workshops delivered to CCBSE researchers in Y2. CCBSE leads will develop a blanket NDA and MTA for CCBSE by the end of Y2. Y2 ACTUAL: Completed	Ensure that all necessary compliance protocols (IBC, MTAs) are in place at all campuses Y3 Annual Report: All compliance documents are in place; active collaborations are on going.	Ensure that all necessary compliance protocols (IBC, MTAs) are in place at all campuses	Ensure that all necessary compliance protocols (IBC, MTAs) are in place at all campuses

Objective 1.2b: Characterize the scaffolds and demonstrate cancer cell growth (Activity 1: Determine mechanical properties, cell viability in the scaffolds, analyze gene expression profiles)	Complete characterizations on the scaffolds prepared in 1.2a. Demonstrate growth of MCF7 and PC3a cells. Y1 Annual Report: On track to complete Y1 ACTUAL: Completed characterizations on the 3 soft polymeric scaffolds from 1.2a; growth of MCF7 and PC3a cells was demonstrated.	Demonstrate growth of MDA-MB-231 and PC3 cells and compare with MCF7 and PCa Y2 Annual Report: The "first generation" scaffolds did not support cell growth. Studies are in progress with the pH-controlled scaffolds. Y2 ACTUAL: Studies on the growth of MCF7 and PC3 cells are in progress on one of the soft scaffolds identified in Objective 1.2a.	Demonstrate tumoroid formation (critical) Y3 Annual Report: Cancer cell growth demonstrated.	Time evaluation of tumor growth on optimized scaffolds	The tumors on the scaffold are genetically and morphologically similar
Objective 1.2b: (Activity 2: Assist non-RU campuses involved in Activity 1 with compliance protocols) *[Change in metric approved by NSF on 7/28/21]*	Assist with the initiation of conversations between non-RU faculty and RU campuses for the administration of necessary compliance protocols (IBC, MTAs) Y1 Annual Report: N/A Y1 ACTUAL: Change under review by NSF.	Ensure that all necessary compliance protocols are in place at the non-RU campuses Y2 Annual Report: Per NSF policy, IBC protocols are not required of non-RU CCBSE researchers. See PROSPER P&C regarding workshops delivered to CCBSE researchers in Y2. CCBSE leads will develop a blanket NDA and MTA for CCBSE by the end of Y2. Y2 ACTUAL: Completed	Ensure that all necessary compliance protocols (IBC, MTAs) are in place at all campuses Y3 Annual Report: All in place.	Ensure that all necessary compliance protocols (IBC, MTAs) are in place at all campuses	Ensure that all necessary compliance protocols (IBC, MTAs) are in place at all campuses
Objective 1.3a: (Activity 1: Design and develop stimuli-responsive polymeric materials as nanocarriers)	Prepare 5 different PSEs and characterize nanoparticles. Y1 Annual Report: On track to complete Y1 ACTUAL: Developed 5 different PSEs and chazcterized them. Optimized one of them as the most suitable PSE.	Demonstrate drug release in the tumoroids cells in scaffolds Y2 Annual Report: Degradation studies of the nanoparticles are in progress in low pH values. Y2 ACTUAL: Degradation studies are in progress.	The nanoparticles release drugs within desirable time in scaffolds (critical) Y3 Annual Report: Prepared two polymers; characterization in progress.	Prepare 3 different polymers, demonstrate imaging in the tumor cells in 3D scaffolds	Released drugs kill majority of cancer cells in scaffold/models

Objective 1.3b: (Activity 1: Design and develop silicon quantum dots (QDs) and polymer-QDs hybrids for bioimaging)	QDs with stable signal in cells Y1 Annual Report: On track to complete Y1 ACTUAL: Completed	Demonstrate good biocompatibility with cancer cell lines Y2 Annual Report: Biocompatibility studies with cancer cells are in progress. Y2 ACTUAL: Studies continue to be in progress.	Identify two polymers (critical) Y3 Annual Report: Prepared the QDs and characterized; cellular imaging studies are in progress.	Make two polymer-SiQD hybrids	Demonstrate optimized imaging
Objective 1.3c: Design and test polymer nanoparticles for vascular surrogacy (Activity 1: Design, preparation, and testing of hypoxiaresponsive polymer nanoparticles)	Prepare 3 polymers with different hypoxia-responsive units, characterize nanoparticles. Y1 Annual Report: On track to complete Y1 ACTUAL: Prepared three polymer nanoparticles.	Prepare two additional polymers, demonstrate drug release in the tumoroids on hard and soft scaffolds. Y2 Annual Report: Studying the release of metarrestin from the nanoparticles under various oxygen levels. Y2 ACTUAL: Polymer synthesis and release studies without any cells are complete. However, we are waiting for the optimal hard and soft scaffolds.	The nanoparticles release drugs within 2 hours in the hard and soft scaffolds (critical). Y3 Annual Report: Drug release in cancer cells from the nanoparticles demonstrated; optimization studies are in progress.	Release drugs kill at least 80% of the breast and prostate cancer cells on the scaffolds (critical)	Released drugs kill at least 80% of the cancer cells in the patient-derived model.
Objective 1.3c (Activity 2: Design, preparation, and testing of pH-responsive polymer nanoparticles)	Prepare 3 polymers, characterize nanoparticles Y1 Annual Report: On track to complete. Y1 ACTUAL: Prepared and characterized 3 pH-responsive polymer nanoparticles.	Demonstrate drug release in the tumoroids on hard and soft scaffolds Y2 Annual Report: Validation ongoing in provided scaffolds. Y2 ACTUAL: Validation of the scaffolds and the selection process are ongoing.	The nanoparticles release drugs within 2 hours in the hard and soft scaffolds (critical) Y3 Annual Report: Release optimization studies are in progress.	Release drugs kill at least 80% of the breast and prostate cancer cells on the scaffolds (critical)	Released drugs kill at least 80% of the cancer cells in the patient-derived model

Color Key:	Behind Schedule	On Track / In-Progress	Ahead of Schedule / Complete	N/A or Not yet started

TABLE 2. CCBSE CELLULAR SYSTEMS AT MATERIALS INTERFACE PILLAR OUTPUT METRICS

CCBSE: Cellular Systems at Materials Interface Pillar	Year 1 July 1, 2020-June 30, 2021	Year 2 July 1, 2021-June 30, 2022	Year 3 July 1, 2022-June 30, 2023	Year 4 July 1, 2023-June 30, 2024	Year 5 July 1, 2024-June 30, 2025
Objective 2.1a: Increase CCBSE capacity/expertise in basic and translational use of in vivo-like 3D cell cultures (Activity 1: Validate multiple soft and hard tissue scaffolds)	Validation SOP creation using existing materials and 2D culture Y1 Annual Report: Behind schedule Y1 ACTUAL: We have created SOPs based on commercially available materials and 2D culture; first gen soft scaffold materials failed to support growth, second gen materials not yet available for testing.	*Metric was not completed in Y1 as planned* Y2 Annual Report: Second gen materials are available for testing. Y2 ACTUAL: Second gen materials are available for testing.			
Objective 2.1a (Activity 1 - cont.)	Protocol database creation based on validation Y1 Annual Report: On track to complete Y1 ACTUAL: Database created and protocols are being uploaded by the team.	Completion of secondary validation on provided 1st generation materials Y2 Annual Report: Validation incomplete since first generation materials failed initial screening. Y2 ACTUAL: Validation incomplete since first generation materials failed initial screening.	Completion of tertiary validation, provided 1st generation materials Y3 Annual Report: tertiary validation awaits suitable 1st generation materials	Completion of quaternary validation, provided 1st generation materials	Completion of quaternary validation, provided 2nd generation materials
Objective 2.1a (Activity 1 - cont.)	Reagent database creation based on validation Y1 Annual Report: On track to complete Y1 ACTUAL: Reagent database created and will be updated continuously.	Completion of preliminary validation on provided 2nd generation materials Y2 Annual Report: Validation ongoing as materials continue to arrive in labs. Y2 ACTUAL: Validation ongoing as materials continue to arrive in labs.	Completion of secondary validation, provided 2nd generation materials Y3 Annual Report: Validation ongoing	Completion of tertiary validation, provided 2nd generation materials	

Objective 2.1a (Activity 1 - cont.)	Completion of preliminary evaluation of provided first generation materials (baseline viability and growth, initial hypoxic response and EMT/MET signatures) i.e., 85% similar to 2D and Matrigel cultures Y1 Annual Report: On track to complete Y1 ACTUAL: First gen hard scaffold work completed. First gen soft scaffold materials did not work, second gen materials not provided during Y1.	*Metric was not completed in Y1 as planned* Y2 Annual Report: Second gen materials are available for testing. Y2 ACTUAL: Second gen materials are available for testing.	Completion of preliminary nanomaterial delivery assessments Y3 Annual Report: update not available at this time	Completion of secondary nanomaterial delivery assessments	Completion of tertiary nanomaterial delivery assessments
Objective 2.1a (Activity 1 - cont.)	Data exchange with Materials Design and Computational Approaches Pillars Y1 Annual Report: On track Y1 ACTUAL: Data exchange initiated and is continuing.	Continued data exchange with Materials Design and Computational Approaches Pillars Y2 Annual Report: Data exchange is continuous and will not be complete until year ends. Y2 ACTUAL: Data exchange is continuous and will not be complete until year ends.	Continued data exchange with Materials Design and Computational Approaches Pillars Y3 Annual Report: ongoing and will continue until year ends	Continued data exchange with Materials Design and Computational Approaches Pillars	Continued data exchange with Materials Design Pillar and Computational Approaches Pillar
Objective 2.1a (Activity 2: Generate heterogeneous multicellular 3D cultures with improved in vivo-like tissue)	A protocol for growth of multi-cellular cultures on provided hard and soft 1st generation materials Y1 Annual Report: On track to complete Y1 ACTUAL: Incomplete, as materials failed/ not provided respectively.	An optimized co-culture protocol for growth on provided hard and soft 1st generation materials Y2 Annual Report: Co-culture cannot be tested until single cell culture validation of first generation materials is completed, as noted above. Y2 ACTUAL: Co-culture cannot be tested until single cell culture validation of first			

		generation materials is completed, as noted above.			
Objective 2.1a (Activity 2 - cont.)		A co-culture protocol for growth on provided hard and soft 2nd generation materials Y2 Annual Report: Second generation materials have been received and validation is ongoing. Y2 ACTUAL: Second generation materials have been received and validation is ongoing.	An optimized co-culture protocol for growth on provided hard and soft 2nd generation materials Y3 Annual Report: co-culture method validation in progress using commercial materials until hard/soft scaffolds show greater promise		
Objective 2.1a (Activity 2 - cont.)		Establish phenotype marker criteria (i.e., morphology and proteins) for co-cultures on provided hard and soft 1st generation materials to compare to *in vivo* tumors Y2 Annual Report: We have a source of PDX tumor tissue; experiments are starting on this metric. Y2 ACTUAL: We have a source of PDX tumor tissue; experiments are starting on this metric.	Establish phenotype marker criteria (i.e., morphology and proteins) for co-cultures on provided hard and soft 2nd generation materials to compare to in vivo tumors Y3 Annual Report: preliminary co-culture experiments have begun, marker analysis currently in progress	Genomic and transcriptomic characterization of co-cultures on hard and soft materials	Genomic and transcriptomic characterization of nanocarrier-mediated drug delivery to co-cultures on hard and soft materials
Objective 2.1a (Activity 2 - cont.)			Protocol for nanocarrier design and drug delivery to 3D-cultures Y3 Annual Report: update not available at this time	Optimized protocol for nanocarrier design and drug delivery to 3D-cultures	Demonstration of nanocarrier-mediated drug delivery effects on co-culture viability and the established cellular phenotype markers

Objective 2.1a (Activity 2 - cont.)	Continued data exchange with Materials Design and Computational Approaches Pillars Y1 Annual Report: On track Y1 ACTUAL: Data exchange initiated and is continuing.	Continued data exchange with Materials Design and Computational Approaches Pillars Y2 Annual Report: Data exchange is continuous and will not be complete until year ends. Y2 ACTUAL: Data exchange is continuous and will not be complete until year ends.	Continued data exchange with Materials Design and Computational Approaches Pillars Y3 Annual Report: ongoing until year ends	Continued data exchange with Materials Design and Computational Approaches Pillars	Continued data exchange with Materials Design and Computational Approaches Pillars
Objective 2.1a (Activity 3: Develop a high throughput system that combines materials and modeling to create an improved culture paradigm for human *in vivo* relevance)	Successful establishment of PDX colonies as source of test materials Y1 Annual Report: On track to compete Y1 ACTUAL: a breast cancer PDX colony has been established at NDSU, this is supported by a different project and not currently associated with ND-ACES. Administrative efforts are in progress to correct this problem.				
Objective 2.1a (Activity 3 - cont.)	Establishment and maintenance of PDX explant tissues (XOs) in scaffold cultures with greater than 1-month viability Y1 Annual Report: Behind schedule, as noted above Y1 ACTUAL: Administrative efforts in progress to associate established breast cancer PDX with the ND-ACES project before explant testing can begin.	Complex Analysis of phenotypic criteria indicating XO tissues on scaffolds exhibit growth and gene expression characteristics similar to *in vivo* conditions Y2 Annual Report: We have arranged to get PDX tissues from the NDSU Animal Core Facility. Y2 ACTUAL: We have arranged to get PDX tissues from the NDSU Animal Core Facility.	Response to hypoxia/ acidification by XO/scaffolds that mimics the *in vivo* tumor environment Y3 Annual Report: update not available at this time	Successful long-term culture of PDO with TAM/TAF on scaffolds	Changes in PDO/scaffold growth behavior, genetics, and morphology upon the intervention of TAM-PDO communication

Objective 2.1a (Activity 3 - cont.)	Development of standard protocols for sustained growth of XO tissues on next generation material scaffolds Y1 Annual Report: Behind schedule Y1 ACTUAL: Administrative efforts in progress to associate established breast cancer PDX with the ND-ACES project before explant testing can begin.	Faster and more efficient growth of XO tissues under scaffold conditions when compared to in vivo maintenance Y2 Annual Report: We have arranged to get PDX tumor tissue *ex vivo* from the NDSU Animal Core Facility. Y2 ACTUAL: We have arranged to get PDX tumor tissue ex vivo from the NDSU Animal Core Facility.	Development of a standard protocol for successful co-culture of XO with TAM/TAF on scaffolds Y3 Annual Report: PDO cultures currently under evaluation in co-culture with endothelial cells	Presentation of miniature tumor microenvironment by PDO/TAM/TAF on scaffolds that is similar to TME of PDX tumor	Presentation of drug resistance characteristics by explanted tumoroids that maintain similar properties to those observed *in vivo*
Objective 2.1a (Activity 3 - cont.)		Successful growth of PDO on the next-generation scaffolds Y2 Annual Report: PDO's have been established in conventional culture, assessment in scaffolds is underway. Y2 ACTUAL: PDO's have been established in conventional culture, assessment in scaffolds is underway.	Complex Analysis of phenotypic criteria indicating PDO tissues on scaffolds exhibit growth and gene expression characteristics similar to *in vivo* conditions Y3 Annual Report: marker analysis of PDO cultures underway for subsequent comparison with in vivo-derived tissues.		
Objective 2.1a (Activity 3 - cont.)	Continued data exchange with Materials Design and Computational Approaches Pillars Y1 Annual Report: On track Y1 ACTUAL: In progress, this is a continuous process.	Continued data exchange with Materials Design and Computational Approaches Pillars Y2 Annual Report: data exchange is continuous and will not be complete until year ends. Y2 ACTUAL: data exchange is continuous and will not be complete until year ends.	Continued data exchange with Materials Design and Computational Approaches Pillars Y3 Annual Report: ongoing until year ends	Continued data exchange with Materials Design and Computational Approaches Pillars	Continued data exchange with Materials Design and Computational Approaches Pillars

Objective 2.1a (Activity 4: Assist non-RU campuses involved in Activity 1 with compliance protocols) *[Metric change approved by NSF on 7/28/21]*	Assist with the initiation of conversations between non-RU faculty and RU campuses for the administration of necessary compliance protocols (IBC, MTAs) Y1 Annual Report: N/A Y1 ACTUAL: Change under review by NSF	Ensure that all necessary compliance protocols are in place at the non-RU campuses Y2 Annual Report: Per NSF policy, IBC protocols are not required of non-RU CCBSE researchers. See PROSPER P&C regarding workshops delivered to CCBSE researchers in Y2. CCBSE leads will develop a blanket NDA and MTA for CCBSE by the end of Y2. Y2 ACTUAL: Per NSF policy, IBC protocols are not required of non-RU CCBSE researchers. See PROSPER P&C regarding workshops delivered to CCBSE researchers in Y2. CCBSE leads will develop a blanket NDA and MTA for CCBSE by the end of Y2.	Ensure that all necessary compliance protocols (IBC, MTAs) are in place at all non-RU campuses Y3 Annual Report: the objective is complete and will only need to be revisited should composition of non-RU campus activities change	Ensure that all necessary compliance protocols (IBC, MTAs) are in place at all non-RU campuses	Ensure that all necessary compliance protocols (IBC, MTAs) are in place at all non-RU campuses

Color Key:	Behind Schedule	On Track / In-Progress	Ahead of Schedule / Complete	N/A or Not yet started

TABLE 3. CCBSE: COMPUTATION, MACHINE LEARNING, AND PREDICTIVE MODELING PILLAR OUTPUT METRICS

CCBSE: Computation, Machine Learning, and Predictive Modeling Pillar	Year 1 July 1, 2020-June 30, 2021	Year 2 July 1, 2021-June 30, 2022	Year 3 July 1, 2022-June 30, 2023	Year 4 July 1, 2023-June 30, 2024	Year 5 July 1, 2024-June 30, 2025
Objective 3.1: Create an evolutionary in-silico platform to predict tumor growth (Activity 1: Machine learning to understand cellular and materials connections)	C7-ML Bone site - Classification Accuracy >=0.4 Y1 Annual Report: On track to meet Y1 ACTUAL: Databases of cancer tissue images were used to identify best performing ML algorithms. Classification Accuracy >=0.4 has been achieved.	C7 ML Bone site - Classification Accuracy >=0.5 Y2 Annual Report: Discussion with Cellular Systems pillar to identify experimental data necessary for ML is taking place. Y2 ACTUAL: Discussion with Cellular Systems pillar to identify experimental data necessary for ML is taking place.	C7 ML Bone site – Classification Accuracy >=0.6 Y3 Annual Report: Discussion with Cellular pillar to identify experimental data necessary taking place		
Objective 3.1: (Activity 1 - cont.)	C8-ML Primary site - Datasets generation from composite data sources for ML model training & identification of best performing ML algorithms for image recognition of the 4 types of cancer cells on bone stem cells Y1 Annual Report: On track to meet Y1 ACTUAL: Databases of cancer tissue images were used to identify best performing ML algorithms and image recognition of at least 4 was achieved.	C8 ML Primary site - 1) Datasets generation for the cellular growth-material formulation using data from experimentalists and other collaborators. Identification of high performing ML algorithms on image recognition for cell migration and clustering Y2 Annual Report: Discussion with Cellular pillar to identify experimental data necessary for ML is taking place. Y2 ACTUAL: Discussion with Cellular pillar to identify experimental data	C8 ML Primary site - Determination of patterns & optimal properties via ML Y3 Annual Report: Discussion with Cellular pillar to identify experimental data necessary taking place.		

		necessary for ML is taking place.			
Objective 3.1: (Activity 1 - cont.) *[Metric change approved by NSF 8/27/21]*		Build Machine learning capacity at a PUI and determine Y3-5 PUI researcher activity Y2 Annual Report: PUI investigator with ML expertise added, will collaborate with existing ML researcher to develop PUI content. Y2 ACTUAL: PUI investigator with ML expertise added, will collaborate with existing ML researcher to develop PUI content.	TBD, see Y2 Y3 Annual Report: The PUI investigator is collaborating with ML researcher to develop PUI content		
Objective 3.1: Activity 2: Multiscale modeling with Materials Design Pillar)	M1-Ab-initio/DFT-Obtain binding interface information at the atomistic level Y1 Annual Report: On track to complete Y1 ACTUAL: Binding affinity of 13 amino acids with clays completed.	M1-Ab-initio/DFT - Obtain binding interface information at the atomistic level Y2 Annual Report: Electrostatic description of amino acids and clays on binding obtained. Y2 ACTUAL: Electrostatic description of amino acids and clays on binding obtained.	M1-Ab-initio/DFT - Obtain binding interface information at the atomistic level Y3 Annual Report: update not available at this time		
Objective 3.1: (Activity 2 - cont.)	M2-Ab-initio/DFT -Building atomistic models to understand interfaces Y1 Annual Report: On track Y1 ACTUAL: Ab-initio/DFT modeling of clay is completed.	M2-Ab-initio/DFT - Building atomistic models to understand interfaces Y2 Annual Report: Integrin model is identified. Specific domains to be used for the calculations are to be finalized. Y2 ACTUAL: Integrin model is identified. Specific domains to be used for the	M2-Ab-initio/DFT - Building atomistic models to understand interfaces Y3 Annual Report: RGD clay models developed and simulations are in progress		

		calculations are to be finalized.			
Objective 3.1: (Activity 2 - cont.)	M3-Molecular Dynamics - Successful model development Y1 Annual Report: On track to complete Y1 ACTUAL: MD model for the PCN being currently used by other pillars is complete.	M3-Molecular Dynamics - Successful model development; compare mechanical properties with nanoindentation with results within an order of magnitude Y2 Annual Report: MD model for a new nanocomposite for hard scaffolds under development. The MD nanoclay model with a new amino acid is built. Y2 ACTUAL: MD model for a new nanocomposite for hard scaffolds under development. The MD nanoclay model with a new amino acid is built.	M3-Molecular Dynamics - Successful model development; compare mechanical properties with nanoindentation with results within an order of magnitude Y3 Annual Report: MD model for a new nanocomposite for hard scaffolds under development. The MD nanoclay model with new amino acid is built		
Objective 3.1: (Activity 2 - cont.)	M4-Coarse Graining - CG model of clay developed; CG model of polymer developed; CG force field validated Y1 Annual Report: On track Y1 ACTUAL: CG model of clay is developed and validated; CG modeling strategy of polymer is established and the CG polymer model is under development.	M4-Coarse Graining - CG model of clay developed; CG model of PCN developed; CG force field validated Y2 Annual Report: Polymer PCL CG model is under development. Y2 ACTUAL: Polymer PCL CG model is under development.	M4-Coarse Graining - CG model of clay developed; CG model of PCN developed; CG force field validated Y3 Annual Report: Polymer PCL CG model is under development		

Objective 3.1: (Activity 2 - cont.)	M5-Finite Element Modeling - Successful model development Y1 Annual Report: On track to complete Y1 ACTUAL: FEM model for the scaffold currently used by other pillars is complete.	M5-Finite Element Modeling - Successful model development. Elastic modulus within an order of magnitude of nanoindentation/ macroscale experiments Y2 Annual Report: Simulations will be done in Y2. Y2 ACTUAL: Simulations will be done in Y2.	M5-Finite Element Modeling - Successful model development. Elastic modulus within an order of magnitude of nanoindentation/ macroscale experiments Y3 Annual Report: Simulations are in progress		
Objective 3.1: (Activity 2 - cont.)	M6-Deterministic models for degrading scaffold under shear flows developed; Rate of degrading validated Y1 Annual Report: On track Y1 ACTUAL: Computational model for shear flows developed; the model for degrading is being developed.	M6-Computational Fluid Dynamics - Range of model parameters for degradable scaffold established; Models for cell interaction and migration developed Y2 Annual Report: CFD simulations of flow through scaffolds in progress. Y2 ACTUAL: CFD simulations of flow through scaffolds in progress.	M6-Computational Fluid Dynamics - Multi-resolution CFD model for scaffold developed; Local distribution of shear stresses in complex geometries validated Y3 Annual Report: CFD simulations in vertical bioreactor are completed. CFD modeling of horizontal bioreactor will begin in Y3		
Objective 3.1: (Activity 3: Multiscale modeling with Cellular Systems Pillar)	C1-Ab-initio/DFT Bone site - Creation of reduced models for integrin domains, nanoclays, and polymers Y1 Annual Report: On track Y1 ACTUAL: Integrin molecular model is identified. Clay model to be used for the study has been developed.	C1-Ab-initio/DFT Bone site - Validation and improvement of reduced models for nanoclays and polymers interacting with Integrin domains Y2 Annual Report: Modeling is in progress Y2 ACTUAL: DFT studies on all 11 non-natural amino acids completed	C1-Ab-initio/DFT Bone site Y3 Annual Report: modeling with RGD and Clay in progress	C1-Ab-initio/DFT Bone site	C1-Ab-initio/DFT Bone site

Objective 3.1: (Activity 3 - cont.)	C2-Ab-initio/DFT - Building atomistic models to model bio-interfaces Y1 Annual Report: On track to complete Y1 ACTUAL: Integrin molecular model is identified.	C2-Ab-initio/DFT - Building atomistic models to represent/model bio-interfaces Y2 Annual Report: Modeling is in progress Y2 ACTUAL: DFT studies on all 11 non-natural amino acids interacting with clay completed	C2-Ab-initio/DFT Primary site - Building atomistic models to model bio interfaces Y3 Annual Report: modeling with RGD interfacing with clay in progress	C2-Ab-initio/DFT Primary site	C2-Ab-initio/DFT Primary site - Building atomistic models to represent/model bio-interfaces
Objective 3.1: (Activity 3 - cont.)	C3-Molecular Dynamics - Successful model development of actin and integrin. Obtaining mechanical properties of actin from SMD Y1 Annual Report: On track to complete Y1 ACTUAL: Both tasks are completed- actin results are published in a Journal paper.	C3-Molecular Dynamics - Successful model development of actin and depolymerization genes; integrin on surfaces; Obtaining mechanical properties of actin and integrin from SMD Y2 Annual Report: The model development of actin and depolymerization genes is completed and the results will be submitted soon to a Journal. The integrin modeling is complete and simulations are ongoing. Y2 ACTUAL: The model development of actin and depolymerization genes is completed and the results will be submitted soon to a Journal. The integrin modeling is complete and simulations are ongoing.	C3, C9, C10-Molecular Dynamics - Determine the mechanical properties of E-Cadherin junctions; Determine the mechanical properties of the integrin molecules on PCN and polymers Y3 Annual Report: MD simulations of integrin with clay in progress. Identification of E-cadherin molecule in progress.	C3, C9, C10-Molecular Dynamics - Determine the mechanical properties of the additional six integrin molecules on PCN and polymers	C11-Multibody dynamics simulations integrated with Finite Element Modeling - Successful development of multibody dynamics simulations model for cell migration

Objective 3.1: (Activity 3 - cont.)	C4-Coarse Graining - CG model of integrins developed; Integrins-PCN interfacial interactions captured by CG modeling Y1 Annual Report: On track Y1 ACTUAL: CG modeling framework of interface is established, and CG model of integrins has been developed.	C4-Coarse Graining – Continued Y2 Annual Report: Awaiting MD results for parameter development. Y2 ACTUAL: Awaiting MD results for parameter development.	C4-Coarse Graining - Mechanical properties of interphases obtained with CG modeling for six integrins and varying interfacial design parameters Y3 Annual Report: MD results for integrin are now available to continue CG development of integrin.	C4-Coarse Graining - Mechanical properties of interphases obtained with CG modeling for additional six integrins with extended interfacial design parameters	
Objective 3.1: (Activity 3 - cont.)	C5-Finite Element Modeling - Successful development of FEM cell model Y1 Annual Report: On track Y1 ACTUAL: FEM model of single cells is completed and nonlinear material properties are being evaluated.	C5-Finite Element Modeling –Successful development of FEM cell model on substrate; incorporation of adhesion parameters from C1 through C4; calibration with experiments Y2 Annual Report: Adhesion models under development. Y2 ACTUAL: Adhesion models under development.	C5-Finite Element Modeling - Successful development of FEM cell model on substrate and Cell-Cell adhesion model; incorporation of adhesion parameters from C1 through C4; calibration with experiments Y3 Annual Report: adhesion parameters will be found from integrin clay modeling and cell-substrate pulling experiments. Both activities are ongoing.		
Objective 3.1: (Activity 3 - cont.)	C6-Computational Fluid Dynamics - Continuum representation of actin networks in cell membrane developed; Cell adhesion model developed and validated Y1 Annual Report: On track Y1 ACTUAL: The DPD model for actin network of cellular membrane has been developed. The result has been published in a Journal article. The	C6-Computational Fluid Dynamics - Models for cell migration on a clay substrate developed and validated Y2 Annual Report: A realistic model for eukaryotic cells has been developed. The migration model is being developed. Y2 ACTUAL: A realistic model for eukaryotic cells has been developed. The	C6-Computational Fluid Dynamics - CFD simulations of flows around groups of cancer cells populated on a substrate Y3 Annual Report: Simulations are in progress	C6-Computational Fluid Dynamics - Using measures such as cell density and alignment to validate CFD models for cellular migration on the surface of scaffold	C6-Computational Fluid Dynamics - Full-scale simulation of cell migration in a bio-reactor. Resolution provides from millimeter to micrometer (three order of magnitudes). Flow distribution and shear stresses will be provided in all pores of the scaffold

	adhesion model is being developed.	migration model is being developed.			
Objective 3.1: (Activity 4: Machine learning to develop the in-silico platform)			C12, C14, C15, C16, C18-ML Bone Site - Obtain the knowledge to construct preliminary rules of designing new scaffold materials for bone site. Classification Accuracy >=0.6 Y3 Annual Report: update not available at this time	C12, C14, C15, C16, C18-ML Bone Site - Obtain the knowledge to construct fundamental rules of designing new scaffold materials for bone site; Classification Accuracy >=0.7; Generate simulated datasets under perturbed conditions and use those datasets to build ML models for cell migration; ML predictive models derived; ML model predictions validated against modeling and experiments	C12, C14, C15, C16, C18-ML Bone Site - Accuracy >=0.8; ML predictive models derived; ML model predictions validated against modeling and experiments; obtain the knowledge to construct fundamental rules of designing new scaffold materials for bone site
Objective 3.1: (Activity 4 - cont.)				C12, C14, C15, C16, C18-ML Bone Site - ML predictive models derived; ML model predictions validated against modeling and experiments; obtain the knowledge to construct fundamental rules of designing new scaffold materials for bone site	

Objective 3.1: (Activity 4 - cont.)			C13, C14, C15, C16, C18-ML Primary Site - Obtain the knowledge to construct preliminary rules of designing new scaffold materials for primary site. Statistical and reduced order models will be developed to predict where cancer cells migrate and grow Y3 Annual Report: update not available at this time	C13, C14, C15, C16, C18-ML Primary Site - ML predictive models derived; ML model predictions validated against modeling and experiments; obtain the knowledge to construct fundamental rules of designing new scaffold materials for primary site	C13, C14, C15, C16, C18-ML Primary Site - Accuracy >=0.8; ML predictive models derived; ML model predictions validated against modeling and experiments; obtain the knowledge to construct fundamental rules of designing new scaffold materials for primary site
Objective 3.1: (Activity 4 - cont.) *[Metric change approved by NSF 8/27/21]*			PUI researcher activity TBD, based on Y2, activity #1 Y3 Annual Report: update not available at this time	PUI researcher activity TBD, based on Y2, activity #1	PUI researcher activity TBD, based on Y2, activity #1
Objective 3.1: (Activity 5: Design Rules)				C17, C12, C13, C14, C15, C16, C18-Parameter-structure-property relationships drawn for design of materials; optimized design parameters identified; develop design rules (geometry, material properties) for fluid flows in degradable scaffolds	C17, C12, C13, C14, C15, C16, C18-Formulation of updated design rules for materials and scaffolds - Parameter-structure-property relationships refined for design of materials; materials design parameters finalized; validate design rules and establish optimized ranges of parameters

Color Key:	Behind Schedule	On Track / In-Progress	Ahead of Schedule / Complete	N/A or Not yet started

TABLE 4. CCBSE OVERALL METRICS

Center for Cellular Biointerfaces in Science and Engineering (CCBSE) Overall	Year 1 July 1, 2020-June 30, 2021	Year 2 July 1, 2021-June 30, 2022	Year 3 July 1, 2022-June 30, 2023	Year 4 July 1, 2023-June 30, 2024	Year 5 July 1, 2024-June 30, 2025
Number of new hires		Y2 Annual Report: UND - 1 hired: Binglin Sui NDSU - Initial virtual interviews have been completed. Spring 2022 campus interviews. On track for Fall 2022 start Y2 ACTUAL: UND - 1 hired NDSU - hire to start work in Y3 on 8/16/22	2 hired: NDSU new materials science faculty member will be hired Y3 Annual Report: NDSU's hire, Prakash Selvakumar, started on 9/26/2022	Retained	5-yr goal: 2 Total to date: 2 hired
Total number of peer-review publications	Y1 Annual Report: 13 Y1 ACTUAL: 14** *Update*: *Y1 Actual revised to 11* as 3 were later removed from the total as they did not pertain to ND-ACES *Update*: During Y2, notified that 3 articles had been published during Y1, *bringing Y1 award year published articles to 14*. ***Update*: end Y2 into Y3, a review is being done of all publications. Will post any updates pertaining to Y1 after review is completed.	Y2 Annual Report: 6 Y2 ACTUAL: 14 2 additional articles submitted in Y2 award year are in Submitted status.	Continue toward goal Y3 Annual Report: 9 through January 31, 2023.	Continue toward goal	5-yr goal: 140 Total published to date: 37

Number of collaborative products/ outputs from one senior author from two or more ND-ACES institutions *[Metric change approved by NSF 5/16/22]*	Y1 Annual Report: 0 Y1 ACTUAL: 0	Y2 Annual Report: 0	Continue toward goal Y3 Annual Report Collaborative products/ outputs under new metric change: Patents: 0 Presentations: 8 (2 with TCU, 1 with PUI and TCU) Proposal submissions: 3 Publications: 0	Continue toward goal	5-yr goal: 70 (with 35 of 70 including a MCU, PUI, TCU senior member) Total to date: 11 (4 with MCU, PUI, or TCU senior member)
Total number of conference presentations by CCBSE senior personnel	Y1 Annual Report: 15 Y1 ACTUAL: 28	Y2 Annual Report: 9 Y2 ACTUAL: 28	Continue toward goal Y3 Annual Report: 21	Continue toward goal	5-yr goal: 90 Total to date: 77
Total number of submitted research proposals (PI/Co-PI from two or more ND-ACES institutions)	Y1 Annual Report: 0 Y1 ACTUAL: 1	Y2 Annual Report: 2 Y2 ACTUAL: 2	Continue toward goal Y3 Annual Report: 0	Continue toward goal	5-yr goal: 50 Total to date: 3
Number of submitted collaborative proposals (two or more ND-ACES senior personnel)	Y1 Annual Report: 2 Y1 ACTUAL: 6	Y2 Annual Report: 3 Y2 ACTUAL: 6	Continue toward goal Y3 Annual Report: 0	Continue toward goal	5-yr goal: 25 Total to date: 12
Number of CAREER proposals submitted	Y1 Annual Report: 0 Y1 ACTUAL: 0	Y2 Annual Report: 0 Y2 ACTUAL: 0	Continue toward goal Y3 Annual Report: 2	Continue toward goal	5-yr goal: 2-4 Total to date: 2

Total external research funding (million $) – 5-year total is cumulative	Y1 Annual Report: $0; 12 proposals, two collaborative, totaling $14,368,361 were submitted (there were actually 11 submitted totaling $12,083,756 - one was added in twice in error) Y1 ACTUAL: $745,521 (three awarded proposals). 13 proposals, 6 collaborative, totaling $13,783,756 were submitted *UPDATE Y1 ACTUAL*: 2 proposals were later removed from the total as they were from internal campus funding; notified 1 more had been submitted in Y1, *bringing total in award Y1 to 12 submitted proposals* (5 collaborative) totaling $13,708,756 - 2 were awarded, 1 of which was collaborative, for a total of $645,523, 9 were denied, and 1 is still pending).	Y2 Annual Report: $0 awarded at this time; 4 have been submitted in award Y2, 3 are collaborative, for a combined total of $4,523,157 Y2 ACTUAL: A total of 11 proposals submitted in Y2; 2 were later removed for not being allowable, *bringing total down to 9 submitted in award Y2* (5 collaborative) for a total of $9,253,373 submitted - 7 are in a Submitted status, 1 was awarded for a total of $249,118, and 1 was denied.	Continue toward goal Y3 Annual Report: 10 proposals submitted totaling $7,223,451; 5 proposals awarded in Y3 totaling $3,867,045; 2 Y3 proposals in pending status, and 5 Y3 proposals in submitted status	Continue toward goal	5-yr goal: $25M Total to date: 26 proposals submitted for a total of $25,455,364; 7 proposals awarded totaling $4,512,568; 2 proposals submitted in pending status (from Y3) and 6 in submitted status (1 from Y2)
Number of projects funded with private sector partners	Y1 Annual Report: 0 Y1 ACTUAL: 0	Y2 Annual Report: 0 Y2 ACTUAL: 0	Continue toward goal Y3 Annual Report: 1	Continue toward goal	5-yr goal: 12 Total to date: 1

Number of graduate students trained (some may be counted in multiple years)	Y1 Annual Report: 30 Y1 ACTUAL: 56 (3 are STTAR interns) *Update 06/2022*: Of the 3 STTAR interns, none are in any of the ND-ACES research areas.	Y2 Annual Report: 76 (48 are students not counted in Y1 report [3 of 48 are STTAR interns from Summer 2021]) Y2 ACTUAL: 9 graduate students added after Y2 reporting *In total, 80 graduate students active in Y2* ([6 of which are STTAR interns: 3 from Summer 2021 and 3 from Summer 2022, though none are in any of the ND-ACES research areas]).	Continue toward goal Y3 Annual Report: 82 (30 new students in Y3; 3 of the 80 are STTAR interns that carried over from Y2 into Y3)	Continue toward goal	5-yr goal: 140 Total to date: There are 108 unique graduate students to date (6 of which are STTAR students who did not intern in any of the ND-ACES research areas).
Number of conference presentations by graduate students (oral and poster)	Y1 Annual Report: 7 Y1 ACTUAL: 50	Y2 Annual Report: 9 Y2 ACTUAL: 65	Continue toward goal Y3 Annual Report: 63	Continue toward goal	5-yr goal: 120 Total to date: 121
Number of undergraduate students trained (some may be counted in multiple years)	Y1 Annual Report: 20 Y1 ACTUAL: 64 (5 are dREU, 20 are STTAR interns) *Update 06/2022*: 41 students added in Y1 after Y1 report (5 are dREU and 20 are Summer 2021 STTAR interns, though no interns are working in any of the ND-ACES research areas) In total, 63 students active Y1	Y2 Annual Report: 77 (57 are students not counted in Y1 report [20 of the 57 are STTAR interns from Summer 2021]) Y2 ACTUAL: 5 students added after Y2 reporting *In total, 93 students active Y2* (43 of which are STTAR interns: 20 from Summer 2021 and 23 from Summer 2022, though no interns are working in any of the ND-ACES research areas)	Continue toward goal Y3 Annual Report: 71 (36 new in Y3; 23 of 71 are STTAR interns that carried over from Y2 into Y3)	Continue toward goal	5-yr goal: 70 Total to date: There are 118 unique undergraduate students (39 of which are STTAR students who did not intern in any of the ND-ACES research areas).
Number of conference presentations by undergraduate students (oral and poster)	Y1 Annual Report: 0 Y1 ACTUAL: 10	Y2 Annual Report: 0 Y2 ACTUAL: 7	Continue toward goal Y3 Annual Report: 9	Continue toward goal	5-yr goal: 80 Total to date: 19

Seed Funding: seed funding support of $60,000 in Translational Research Initiative Project and an additional $101,655 in other research opportunity support – 5-year total is cumulative *[approved by NSF]*	Y1 Annual Report: Emerging Areas/Seed Award Request for Proposals has been issued and 4 proposals awarded totaling $103,568 Y1 ACTUAL: No change; total seed funding $103,568	Y2 Annual Report: Emerging Areas/Seed Award Request for Proposals have been issued and 5 new proposals awarded totaling $175,162.80 and additional funds totaling $85,508 provided to Y1 awardees, for a total of $260,670.80 Y2 ACTUAL: Total seed funding $260,670.80	Continue toward goal Y3 Annual Report: 2 new Emerging Areas seed awards issued totaling $49,977.00	Continue toward goal	5-yr goal: $161,655 Total to date: $414,215.80
Number of CCBSE research participant meetings (to be scheduled monthly)	Y1 Annual Report: 5 Y1 ACTUAL: 10	Y2 Annual Report: 7 Y2 ACTUAL: 10	Continue toward goal Y3 Annual Report: 9	Continue toward goal	5-yr goal: 50-60 Total to date: 27

Color Key:	Behind Schedule	On Track / In-Progress	Ahead of Schedule / Complete	N/A or Not yet started

TABLE 5. PROSPER: EDUCATION AND WORKFORCE DEVELOPMENT OUTPUT METRICS

PROSPER Element: Education and Workforce Development	Year 1 July 1, 2020-June 30, 2021	Year 2 July 1, 2021-June 30, 2022	Year 3Y3 July 1, 2022-June 30, 2023	Year 4 July 1, 2023-June 30, 2024	Year 5 July 1, 2024-June 30, 2025
"Objective 4.1a: Retain/ advance CCBSE's early career faculty and graduate students (Activity 1: Early Career Faculty Mentoring Program) [Metric changes approved by NSF on 3/9/21 and 5/10/22]"	ECFs retained. ECF PD plans developed and implemented; Set baselines. Monthly Pillar meetings held between CCBSE research leads and faculty as a means of providing mentoring and guidance to ECF faculty. Information gathered from ECF about their mentorship and professional development needs and implemented; set baselines Y1 Annual Report: Developing a mitigation plan that will take baselines set by ECF faculty to identify mentor training materials and/or programs Y1 ACTUAL: Monthly pillar meetings held. Information gathered about ECF professional development needs and mentoring experiences. Baselines set for sense of belonging, work-self-efficacy, professional/ technical transferable skills, turnover intentions, and scholarly productivity	ECFs retained. 1 new faculty member to be hired at NDSU and 1 new faculty member to be hired at UND. Meet/ exceed baselines. Hold monthly Pillar meetings between CCBSE research leads and faculty as a means of providing mentoring and guidance to ECF faculty. PROSPER personnel (at least 2) will engage in training and/or independent study in mentorship best practices via the CIMER Prorproje ct.org/) (Summer-Fall 2021). CIMER Project Trained PROSPER personnel will then train 25% of ND- ACES CCBSE Faculty in mentorship best practices Y2 Annual Report: New Faculty hired at UND. Two EWD Personnel trained and prepared to facilitate mentor training for CCBSE personnel. Four Mentor Training modules delivered in Fall 2021. Remaining modules will be delivered in Spring 2022. Due to scheduling issues as a	5/10/22 new metric: ECFs and new hires retained. Meet/exceed baselines. Hold monthly Pillar meetings between CCBSE research leads and faculty as a means of providing mentoring and guidance to ECF faculty. Y3 Annual Report: New faculty member at NDSU started on 9/26/2022. Monthly Pillar meetings held. Follow-up survey will be completed in March-April 2023.	5/10/22 new metric: ECFs and new hires retained. Meet/exceed baselines. Hold monthly Pillar meetings between CCBSE research leads and faculty as a means of providing mentoring and guidance to ECF faculty.	5/10/22 new metric: ECFs and new hires retained. Meet/exceed baselines. Hold monthly Pillar meetings between CCBSE research leads and faculty as a means of providing mentoring and guidance to ECF faculty.

		result of increased workload issues related to COVID and other external factors, Mentor Training was not fully completed in Fall 2021 ultimately pushing back deadlines for mentor-mentee activities and survey follow-up Y2 ACTUAL: New Faculty hired at UND. Two EWD Personnel trained and prepared to facilitate mentor training for CCBSE personnel. Four Mentor Training modules delivered in Fall 2021 for 11 CCSBE seasoned faculty (25%) and the remaining 6 modules were delivered in June 2022 for 5 CCBSE seasoned faculty. Additional Mentor Training will occur in Y3 of the project. In terms of baseline metrics, Overall, CCBSE early career faculty endorsed a slightly higher average sense of belonging in their respective work environments, with a .11 difference in standard deviations. Although there was a .14 decrease in their reported abilities, they continued to show extremely high levels of confidence in their abilities to successfully complete work tasks and responsibilities (i.e., work self-efficacy) and endorsed a high level of the necessary skills to perform			

		their lab duties (i.e., professional/technical/ transferable skills). CCBSE early career faculty's desire to leave their respective department increased by .46, although the reported average score is still low, which indicates a preserved desire to grow within their program (i.e., turnover intentions).			

Objective 4.1a: (Activity 2: Early Career Faculty Professional Development Activities)	Develop list of ECF professional development activities available and disseminated to ECFs (alternatively develop and implement 2 PD activities); track engagement with PD activities with goal that at least 70% of ECF participate Y1 Annual Report: On track Y1 ACTUAL: List of ECF PD activities developed and information about these activities disseminated to ECF via email. Need to develop a more effective process of tracking participation in said activities.	Develop list of ECF professional development activities available and disseminated to ECFs (alternatively develop and implement 3 PD activities); track engagement with PD activities with goal that at least 70% of ECF participate Y2 Annual Report: We continue to develop list of professional development activities and disseminate information about said activities. Developing PD outreach presentations, infographics, etc. based on baseline survey where information about ECFs PD needs was gathered. Develop tracking mechanism for this activity Y2 ACTUAL: We continue working on this throughout the project.	Develop list of ECF professional development activities available and disseminated to ECFs (alternatively develop and implement 3 PD activities); track engagement with PD activities with goal that at least 70% of ECF participate Y3 Annual Report: We continue to develop list of professional development activities and disseminate information about said activities to appropriate ND-ACES personnel. Developing PD outreach presentations, infographics, etc. based on baseline survey where information about ECFs PD needs was gathered. We have scheduled PD webinars for Feb-May.	Develop list of ECF professional development activities available and disseminated to ECFs (alternatively develop and implement 3 PD activities); track engagement with PD activities with goal that at least 70% of ECF participate	Develop list of ECF professional development activities available and disseminated to ECFs (alternatively develop and implement 2 PD activities); track engagement with PD activities with goal that at least 70% of ECF participate

Objective 4.1a: (Activity 3: Student Research Training Groups (RTG))	10 mentor/mentee pairs will be established; mentor/ mentee pairs will meet monthly; and mentee individual development plan created Y1 Annual Report: On track Y1 ACTUAL: 0 mentor/mentee pairs were established; student list was generated	10 mentor/ mentee pairs will be maintained or established; mentor/mentee pairs will meet monthly; mentee individual development plan created Y2 Annual Report: 14 mentor/ mentee groups were established for 2021-22. Mentor Memo-a monthly mentoring newsletter is sent out each month to encourage monthly conversations between mentors and mentees Y2 ACTUAL: 14 mentor/ mentee groups were established for 2021-22. Mentor Memo-a monthly mentoring newsletter were sent out each month to encourage monthly conversations between mentors and mentees.	10 mentor/ mentee pairs will be maintained or established; mentor/ mentee pairs will meet monthly; transition from mentee to mentor for graduate students progressing; mentee individual development plan created. Y3 Annual Report: ND ACES Teams Site Established. Mentoring Teams were established with mentoring memos created Oct-Dec to support start. No participants as of Dec 1. Journal Club met twice (attendance 3 students, 7 students), other scheduled JC no student volunteered to lead.	10 mentor/ mentee pairs will be maintained or established; mentor/ mentee pairs will meet monthly; transition from mentee to mentor for graduate students progressing; mentee individual development plan created	10 mentor/ mentee pairs will be maintained or established; mentor/ mentee pairs will meet monthly; transition from mentee to mentor for graduate students progressing; mentee individual development plan created

Objective 4.1a: (Activity 3 - cont.)	50% of RTG students present work at one regional/national meeting Y1 Annual Report: On track Y1 ACTUAL: 39% of the 66 RTG students presented their work and 5 of those published (3 of them are a RTG student). *Update July 2022*: 37 of 66 RTG students, or 56%, presented in Y1. 8 students were listed as an author in a publication in Y1; 5 as first author	80% of students present work at one regional/national meeting; 75% of students publish (first author) paper prior to graduation Y2 Annual Report: so far, 8% of 100 RTG students presented their work and the ND EPSCoR conference is being held 4/6/22 where students are expected to present; 5 ACES students are listed first on a publication (3 of them are a RTG student). Y2 ACTUAL: 47 of 100 RTG students, or 47%, presented in Y2. 12 students were listed as an author in a publication in Y1; 8 as first author	80% of students present work at one regional/national meeting; 75% of students publish (first author) paper prior to graduation Y3 Annual Report: 39.7% (46 of 116 students) of Y3 students presented at a regional/national meeting; 11.7% (4 of 34 students who have graduated), were listed as first author in a publication.	80% of students present work at one regional/national meeting; 75% of students publish (first author) paper prior to graduation	80% of students present work at one regional/national meeting; 75% of students publish (first author) paper prior to graduation

Objective 4.1a: (Activity 3: - cont)	Set baselines Y1 Annual Report: On track Y1 ACTUAL: Baselines were set for professional/ technical skills, self efficacy, persistence/ intention, and sense of belonging	Meet/exceed baselines Y2 Annual Report: Survey is being prepared and will be sent out in January 2022 Y2 ACTUAL: Follow-up survey was sent out to ND-ACES students. The baseline survey included 43 participants while the follow-up survey included 23 respondents. In comparison to the baseline survey, follow-up respondents reported slightly higher levels of confidence in their professional/technical skills, scale 1 work self-efficacy, sense of belonging, and persistence and intentions for undergraduate students. Graduate students reported lower persistence and intentions from baseline to follow-up when comparted to undergraduates.	Meet/exceed baselines Y3 Annual Report: Baseline survey was released for new participants in November prior to mentoring groups roll out.	Meet/exceed baselines	Meet/exceed baselines

Objective 4.1a: (Activity 4a: Graduate Student Cyber-infrastructure) *[Metric changes approved by NSF 8/27/21]*	30% of the total participants are trained Y1 Annual Report: On track Y1 ACTUAL: 46/163 (28.2%)	80% response from CCBSE researchers and graduate students to the CI Needs Survey Y2 Annual Report: Survey has been developed and was approved by the PROSPER members. The survey was released on 2/17/22. Survey has been sent to all CCBSE researchers and graduate students. Y2 ACTUAL: Survey was completed by 31 ND-ACES participants across the three science pillars and across six institutions. Findings from the survey will inform CI related training and activities in Y3 of the project and beyond.	2 (1 from CCAST and 1 from CRC) new or customized CI workshops developed; Both workshops offered once during Y3; 10% of CCBSE researchers and graduate students participate in the Y3 workshop or other CI training programs Y3 Annual Report: 1 new CI workshop developed by CCAST.	2 (1 from CCAST and 1 from CRC) new or customized CI workshops developed; Both workshops offered once during Y4; 10% of CCBSE researchers and graduate students participate in the Y4 workshop or other CI training programs	2 (1 from CCAST and 1 from CRC) new or customized CI workshops developed; Both workshops offered once during Y5; 10% of CCBSE researchers and graduate students participate in the Y5 workshop or other CI training programs
Objective 4.1a: (Activity 4a: Graduate Student Cyber-infrastructure)		2 CI GRAs hired Y2 Annual Report: 2 additional awarded (one awarded at NDSU and one at UND; trainings ongoing for Y2) Y2 ACTUAL: CI GRA's extended through June 30th, 2022. RFA for Y3 developed and advertised.	2 CI GRAs hired. Y3 Annual Reports: 2 CI Assistantships awarded in Y3, 2 CI assistantships from Y2 extended	2 CI GRAs hired.	2 CI GRAs hired

Objective 4.1a (Activity 4b: STEM Teaching Assistantship) *[Metric changes approved by NSF 2/9/22, 5/16/22 and 7/8/22]*	*THIS PROGRAM HAS BEEN MOVED TO Y2 DUE TO COVID-19*	Masters and/or Doctoral students receive and complete teaching assistantships at TCUs/PUIs/MCU Y2 Annual Report: TCU/PUI/MCU faculty to request additional summer salary Y2 ACTUAL: 3 doctoral student applicants approved for Y3 by state office. 2 applicants awarded teaching assistantship at MaSU, a third interviewing at NHSC.	Doctoral and/or Masters students receive and complete teaching assistantships at TCUs/PUIs/MCU Y3 Annual Report: For Fall 2022: 2 STEM TAs hired at MaSU, 1 hired at NHSC, and 1 hired at NDSU.	Continued	Continued
Objective 4.1a: (Activity 5: % of participants in Activities 1-4b presenting at a workshop or conference)		95% of participants presenting Y2 Annual Report: 29.3% of participants presented since 7/1/2020 (44 of 150) Y2 ACTUAL: Through Y2, 39.6% presented at a workshop or conference. Cumulative for Y1/Y2, 45% of participants presented	95% of participants presenting Y3 Annual Report: 37.6% of Y3 participants presented.	95% of participants presenting	95% of participants presenting
Objective 4.1b: Engage/ develop K-16 student interest in biosciences (Activity 1: Distributed Research Experience for Undergraduates (dREU))	6 dREU students complete research, and present at the state conference and undergraduate research showcase. Y1 Annual Report: 6 students Y1 ACTUAL: 7 students, of which 5 presented at the ND EPSCoR state conference 2021	12 dREU students complete research and present at the state conference and undergraduate research showcase Y2 Annual Report: 1 new student, 3 still active from Y1. 1 of 4 scheduled to present at the ND EPSCoR state conference 2022; 2 other dREU students are co-researchers on other student presentations Y2 ACTUAL: 2 new dREU presentations and 1 dREU	12 dREU students complete research, and present at the state conference and undergraduate research showcase Y3 Annual Report: 4 dREUs awarded Summer 2022 extended into Y3; 3 new dREUs awarded Fall 2022.	12 dREU students complete research, and present at the state conference and undergraduate research showcase	6 dREU students complete research, and present at the state conference and undergraduate research showcase; 50% of REU students matriculate to graduate/ professional school; 8 REU students in graduate/ professional school

		co-author at 2022 ND EPSCoR conference. 4 dREUs awarded for Summer 2022.			
Objective 4.1b: (Activity 2: Engage grade 6-12 students in NATURE/Sunday Academy)	Baseline was set at 350 students per year Y1 Annual Report: 117 TCU camp students Y1 ACTUAL: 117 TCU students; 3 Bridge Camp students; 298 Sunday Academy participants for 2020/2021	Meet/exceed baselines Y2 Annual Report: 91 Sunday Academy students 2021/2022 as of 1/31/22 * TCU and Bridge camps will be held June/July 2022 Y2 ACTUAL**: There will be no Bridge Camp summer 2022. Additional 117 Sunday Academy students since 1/31/22 ***some Sunday Academy and TC camp attendee counts are still forthcoming for Y2; see data in Y3*	Meet/exceed prior year's numbers Y3 Annual Report: The attendees for the 2022-2023 Sunday Academy program total 247, though some numbers are still not in. Attendees for the remaining Sunday Academies in 2021-2022 that occurred after the Y2 report cutoff totals 130. The attendees for Summer 2022 TCU NATURE camps totaled 140.	Meet/exceed prior year's numbers	Met/exceed prior year's numbers
Objective 4.1b: (Activity 3: Training of Rural and tribal K-12 teachers in the use of PROSPER bioscience modules)	Module 1 developed Y1 Annual Report: On track Y1 ACTUAL: Developed 1 Module	Baselines number of teachers reached set via Module 1. Module 2 developed Y2 Annual Report: Two cellular modules were finalized in Fall 2021, training events for both modules are being planned for Spring 2022 Y2 ACTUAL: Modules developed, but no training events were conducted due to COVID restrictions and personnel changes.	Meet/exceed prior year's training numbers Y3 Annual Report: 4 rural teachers implementing bioscience lesson plans in Fall 2022 and completing a survey for impact tracking and evaluation of lesson plans.	Meet/exceed prior year's training numbers	100 total teachers trained over 5-year period

Objective 4.1b: (Activity 4: Pre-service STEM teachers will engage in rural/tribal student teaching experiences)		2 pre-service teachers trained each semester (Fall/Spring); 2 pre-services teachers placed each semester Y2 Annual Report: 2 student teachers placed for Fall 2021, 1 student teacher placed in Spring 2022, and 1 student teacher recruited for Fall 2022 Y2 ACTUAL: 2 student teachers placed for Fall 2021, 1 student teacher placed in Spring 2022, and 1 student teacher recruited for Fall 2022.	2 pre-service teachers trained each semester; 2 pre-services teachers placed each semester Y3 Annual Report: 1 student teacher recruited for Fall 2022; 2 student teachers placed Spring 2023 For Fall 2023, there are 7 potential candidates.	2 pre-service teachers trained each semester; 2 pre-services teachers placed each semester	2 pre-service teachers trained each semester; 2 pre-services teachers placed each semester

Color Key:	Behind Schedule	On Track / In-Progress	Ahead of Schedule / Complete	N/A or Not yet started

TABLE 6. PROSPER: BROADENING PARTICIPATION OUTPUT METRICS

PROSPER Element: Broadening Participation	Year 1 July 1, 2020-June 30, 2021	Year 2 July 1, 2021-June 30, 2022	Year 3 July 1, 2022-June 30, 2023	Year 4 July 1, 2023-June 30, 2024	Year 5 July 1, 2024-June 30, 2025
Objective 5.1: Increase the participation of all groups engaged in bioscience education and careers (Activity 1: TCU bioscience students will conduct outreach in their local K-12 schools via bioscience lesson plans) *[Metric changes approved by NSF 2/9/22]*	Create five ND-ACES related bioscience lesson plans Y1 Annual Report: 5 high school lesson plans developed from NATURE Sunday Academy STEM activities. Y1 ACTUAL: 5 high school lesson plans with 7 cultural supplements (3 Lakota and 4 Ojibwa) created from NATURE Sunday Academy informal STEM activities.	5 additional ND-ACES related STEM lesson plans Y2 Annual Report: 5 middle school lesson plans with no cultural supplements created from NATURE Sunday Academy informal STEM activities. The next set of NATURE Sunday Academy informal STEM activities will be selected in June 2022. Y2 ACTUAL: Additional lesson plans will be developed Summer 2022.	5 additional ND-ACES related STEM lesson plans Y3 Annual Report: 2 middle school and 2 high school lesson plans have been created. No cultural components have been added.	5 additional ND-ACES related STEM lesson plans	5 additional ND-ACES related STEM lesson plans
Objective 5.1: (Activity 1 - cont.) *[Approved by NSF 2/9/22]*	2 TCU students deliver the bioscience lessons to 40 students Y1 Annual Report: TCU students could not go into K-12 facilities due to the COVID pandemic. Y1 ACTUAL: No change	6-12 grade STEM teachers identified for Y3 and TCU student involvement planned Y2 Annual Report: Efforts are underway to identify 6-12 grade STEM teachers for Y3 activities. Y2 ACTUAL: Working with NATURE Coordinators to identify STEM teachers for Fall.	Fall 2022 and Spring 2023 TCU students identified and introduced to 6-12 grade STEM teachers Y3 Annual Report: Conversations underway with NATURE Coordinators regarding the concerns related to this metric in light of security requirements at K-12 schools, lack of pedagogical training of TCU students, and impact of the loss of classroom time that would be	Fall 2023 and Spring 2024 TCU students identified and introduced to 6-12 grade STEM teachers	Fall 2024 and Spring 2025 TCU students identified and introduced to 6-12 STEM teachers

			devoted to meeting current curricular requirements.		
Objective 5.1: (Activity 1 - cont.)	3 NATURE students matriculating into STEM degrees (either AS or above). Y1 Annual Report: 16 matriculated Y1 ACTUAL: No change	4 NATURE students completing STEM degrees Y2 Annual Report: 8 matriculated and 3 with graduate degrees. Y2 ACTUAL: New tracking in Fall 2022.	4 NATURE students completing STEM degrees Y3 Annual Report: working with TCUs to better collect matriculation data.	4 NATURE students completing STEM degrees	>10 NATURE students with STEM B.S and >5 NATURE students with STEM graduate/ professional degrees over 5 years
Objective 5.1: (Activity 2: Support engagement in biosciences at the B.S. level (particularly for AI)) [A*pproved by NSF 2/9/22]*	Plan research assistantships for juniors and seniors. Year 1 Annual Report: 2 students received assistantships. Y1 ACTUAL: No change	2-3 students will have received research assistantships as juniors and seniors or post-associate assistantships Y2 Annual Report: Current RFA has been extended to post-associate assistantships. Y2 ACTUAL: 1 student identified for post-bac at MiSU.	2-3 additional students will have received research assistantships as juniors and seniors and 1 student will have completed their B.S. degree or post-associate assistantships Y3 Annual Report: Fall 2022, 1 new undergraduate research assistantship awarded	2-3 additional students will have received research assistantships as juniors and seniors and 1 student will have completed their B.S. degree or post-associate assistantships	7-10 students will have received research assistantships as juniors and seniors or post-associate assistantships and 3 of those will have completed their B.S. degree over 5 years

Objective 5.1: (Activity 3: TCU bioscience faculty will be offered research techniques and equipment training) *[Approved by NSF 2/9/22]*	One TCU faculty will visit CCBSE collaborators and learn a research technique/learn a HPC technique/expand knowledge in a Pillar area Year 1 Annual Report: 1 visit by a CCCC faulty member to NDSU. Y1 ACTUAL: No change, as the COVID pandemic continues to interfere with travel.	Survey for TCU STEM faculty re: training preferences developed and distributed. Preferences prioritized. Collaborating institutions' faculty requested to provide training in those areas identified through the survey. One training video on identified areas will be produced and released to TCU faculty. Y2 Annual Report: Survey instrument is being developed for distribution. TCU faculty made aware that requests may be forthcoming. Y2 ACTUAL: Survey will be complete 6/15/22.	Survey of TCU STEM faculty updated Preferences prioritized - continued Provide training - continued Training video - continued Y3 Annual Report: Survey instrument deployed and results summarized internally. New ND EPSCoR Communications Specialist will review data and work with TCU faculty to identify need for and topic for training and training videos.	Survey updated - continued Preferences prioritized - continued Provide training - continued Training video - continue, with two training videos produced and released	Five collaborative projects using the new skills over 5 years Survey updated - continued Preferences prioritized - continued Provide training - continued Training video - continued, with two training videos produced and released
Objective 5.1: (Activity 4: TCU camps for middle and high school kids at the four partnering TCUs)	120 participants Year 1 Annual Report: 0 participants; prior RII Track-1 INSPIRE-ND overlapped with this Track-1 and 117 participants were counted in June/July 2020. Y1 ACTUAL: 126 participants June/July 2021.	140 participants Y2 Annual Report: TCU camps will be held June/July 2022; planning is underway for the TCU camps. Y2 ACTUAL**: Planning occurred June 6-17, 2022. Camps are being held ***some TC camp attendee counts are still forthcoming for Y2. See Y3.*	140 participants Y3 Annual Report: TCU camps totaling 69 attendees occurred during award Y2 after the Y2 report cutoff, and TCU camps totaling 71 attendees occurred during award Y3.	140 participants	680 participants over 5 years

Objective 5.1: (Activity 5: Sunday Academies for middle and high school kids at the four partnering TCUs)	350 participants Y1 Annual Report: 0 participants (due to COVID pandemic, prior RII Track-1 was overlapped and 429 students were counted under INSPIRE-ND). Y1 ACTUAL: 298 Virtual Sunday Academy participants for 2020/2021.	350 participants Y2 Annual Report: 91 Sunday Academy students 2021/2022 as of 1/31/22 (Note: 9 Sunday Academy events postponed due to weather or COVID parameters). Y2 ACTUAL**: Additional 117 Sunday Academy students since 1/31/22 ***some Sunday Academy and TC camp attendee counts are still forthcoming for Y2*	350 participants Y3 Annual Report: Initial planning occurred during the faculty portion of the NATURE University Summer Camp June 2022. Attendees for the 2022-2023 Sunday Academy program total 247, though some numbers are still not in. Attendees for the remaining Sunday Academies in 2021-2022 occurring after the Y2 report cutoff totals 130.	350 participants	1,750 participants over 5 years
Objective 5.1: (Activity 6: Bridge camps for graduating high school seniors at the four partnering TCUs)	10 participants Y1 Annual Report: Camp runs July 2020. Y1 ACTUAL: 0 participants in 2020. 3 participants in July 2021 due to the COVID pandemic; only 2 of 4 TCUs participated.	15 participants Y2 Annual Report: Camp will be held June/June 2022 – planning is underway. Y2 ACTUAL: Planning occurred June 6-17, 2022. *Update July 2022: there was no Bridge camp Summer 2022.*	15 participants Y3 Annual Report: Working group established for NATURE activities.	15 participants	55 participants over 5 years
Objective 5.1: (Activity 7: University Summer Camp for participants)	20 participants Y1 Annual Report: Camp runs June 2021. Y1 ACTUAL: 14 participants in June 2021 virtual camp.	20 participants Y2 Annual Report: Camp runs June 2022. Y2 ACTUAL: Face-to-face camp runs June 6-17 (student portion was cancelled due to renewed concerns around COVID-19 in tribal communities).	20 participants Y3 Annual Report: Working group established for NATURE activities.	20 participants	A total of 100 participants over 5 years

Color Key:	Behind Schedule	On Track / In-Progress	Ahead of Schedule / Complete	N/A or Not yet started

TABLE 7. PROSPER: PARTNERSHIPS AND COLLABORATIONS OUTPUT METRICS

PROSPER Element: Partnerships and Collaborations	Year 1 July 1, 2020-June 30, 2021	Year 2 July 1, 2021-June 30, 2022	Year 3 July 1, 2022-June 30, 2023	Year 4 July 1, 2023-June 30, 2024	Year 5 July 1, 2024-June 30, 2025
Objective 6.1a: Expand the intellectual reach of the CCBSE by building stronger collaborations with other academic institutions and federal labs (Activity 1: Determine and build upon the baseline)	Baseline established by senior personnel Y1 Annual Report: 29 collaborations with 24 academic institutions identified. 23 domestic and 1 international. Y1 ACTUAL: No change	20% increase in meaningful collaborations over prior year Y2 Annual Report: 45 collaborations with 50 academic institutions identified. 49 domestic and 1 international. Y2 ACTUAL: As part of the Y2 RSV response, the team has requested an expansion of the proposal definition of a collaboration	20% increase in meaningful collaborations over prior year Y3 Annual Report: As of January 31, 2023, an additional 4 collaborations have been reported. In total there are 36 ongoing collaborations in Y3 with 106 individuals at 35 institutions and medical facilities.	20% increase in meaningful collaborations over prior year	20% increase in meaningful collaborations over prior year
Objective 6.1a: (Activity 2: Support participant interactions with external collaborators with travel funding) *[Approved by NSF 2/9/22]*			1-3 trips to external collaborators and 1-3 external collaborators coming to campuses Y3 Annual Report: 2 CCBSE applications have been received and both researchers have traveled to meet with their prospective collaborator.	Continued with 2- 6 total visits	Continued with 2- 6 total visits
Objective 6.1a: (Activity 3: Support interactions with external collaborators)			Fund at least one seed award between CCBSE and an external collaborator Y3 Annual Report: This RFP will be released in Fall 2022/Spring 2023.	Continue to fund one seed award per year	Continued

Objective 6.1b: Create pathways for translating research results into commercially viable end products (Activity 1: Determine and build upon the baseline for partnerhips)	Baseline established using CDAs, MTAs, other efforts (grant applications, etc.) Y1 Annual Report: 5 in-state partnerships with 2 organizations. Y1 ACTUAL: No change	20% increase in meaningful collaborations over prior year Y2 Annual Report: 6 in state partnerships with 3 organizations Y2 ACTUAL: As part of the Y2 RSV response, the team has requested an expansion of the proposal definition of a partnership	Increase in partnership engagement or partner activities over the prior year - measured by the increased provision of valuable resources Y3 Annual Report: This will be measured using the new definitions approved by NSF in the mitigation plan. As of January 31, 2023, 9 ongoing partnerships (1 is new) with 5 organizations involving 16 individuals.	Increase in partnership engagement or partner activities over the prior year - measured by the increased provision of valuable resources	Increase in partnership engagement or partner activities over the prior year - measured by the increased provision of valuable resources
Objective 6.1b: (Activity 2: Support Partnerships)	Y1 Annual Report: Identification of Y2 support efforts based on baseline data and determination of measures [# participants (if event), # of inquiries following communication effort, etc.]. Y1 ACTUAL: Provision for 3 informational workshops in Y2	Increased engagement by meeting of prior year's identified support efforts Y2 Annual Report: 3 workshops and 1 conference panel addressing prior year's support needs (initiating interactions with industry) were held and made the decision of use I-Corps for next year's workshops Y2 ACTUAL: Planning is underway for the first I-Corps training session to be held during the September 2022 All-Participants meeting	Increased engagement by meeting of prior year's identified support efforts Y3 Annual Report: UND trainers presented a 1 hour initial I-Corps workshop during the 9/14/22 All-Participants meeting. Exploring partnering opportunities with NSF I-Corps Hub at NDSU.	Increased engagement by meeting of prior year's identified support efforts	Increased engagement by meeting of prior year's identified support efforts

Objective 6.1b: (Activity 3: Identify ND companies using tools like NAICS) *[Metric changes approved by NSF 2/9/22 and 5/10/22]*		Following the April 2022 EAB meeting, together with CCBSE and Pillar leads, begin to develop a CCBSE prospectus for cultivating partnerships and exploring potential funding possibilities Y2 Annual Report: The team will work with UND Center for Innovation to provide I-Corp Hub training (tools/ resources/activities) to participants. Y2 ACTUAL: Team needs will be discussed during the September 2022 All-Participants meeting.	Finalize a CCBSE prospectus Y3 Annual Report: Following the 9/14/22 All-Participants meeting, the PI and co-PIs will meet with the CCBSE leads and the I-Corps lead at UND to determine additional Y3 trainings that will help researchers identify ND companies.	Update CCBSE prospectus	Continued
Objective 6.1b: (Activity 4: Identify partnership opportunities)		Begin to identify 3-5 opportunities, and determine 1-3 of which are actionable by CCBSE leads Y2 Annual Report: The team has limited experience with industry engagement; thus will be well served in Y3 with the NSF I-Corps training platforms. Y2 ACTUAL: Following the September 2022 All-Participants meeting, the PI/PD, co-PIs, and CCBSE leads will meet to determine Y3 priorities.	Identify 3-5 opportunities, 1-3 of which are actionable Y3 Annual Report: Following the 9/14/22 All-Participants meeting, the PI and co-PIs will meet with the CCBSE leads and the NDSU and UND industry development offices to identify partnership opportunities for Y3 (including STTAR internships).	Identify 3-5 opportunities, 1-3 of which are actionable	Identify 3-5 opportunities, 1-3 of which are actionable

Objective 6.1b: (Activity 5: Identify IP protocols at all 10 institutions)	Work with campuses to identify IP protocols with >50% protocols identified Y1 Annual Report: Protocols identified at 2 RUs, 1 MCU, and 3 PUIs – all ND University System campuses: 6 of 10 = 60%. Y1 ACTUAL: No change	100% protocols identified; Collaborative decision made regarding the handling joint IP and updated protocol document Y2 Annual Report: 4 of 4 TCUs surveyed. There are currently no IP protocols in place at the TCUs for invention IP. 2 TCUs (SBC and TMCC) are now working to develop these protocols. Y2 ACTUAL: Agendas, prepared for the annual campus visits, will include a discussion about these protocols and whether the campuses would like assistance.	Up to date protocol document and joint IP agreement Y3 Annual Report: Planning for visits in late spring 2023 where conversations related to IP protocols will continue.	Up to date protocol document and joint IP agreement	Up to date protocol document and joint IP agreement
Objective 6.1b: (Activity 6: Understand how tribal laws impact IP disclosures)	Work with TCU campuses located in ND to identify impacts with 50% identified Y1 Annual Report: 0 identified. The COVID pandemic prevented travel and TCU personnel were busy with the change to online delivery. Y1 ACTUAL: No change	Work with campuses to identify commercialization protocols with 100% protocol identified Y2 Annual Report: 4 of 4 TCUs identified (100%). There are currently no IP protocols in place at the TCUs for invention IP. 2 TCUs (SBC and TMCC) are now working to develop these protocols, which include tribal law. Y2 ACTUAL: See Activity 6.1b #5	Survey developed and released Y3 Annual Report: During the Fall 2022 meeting with the TCU presidents, the feasibility of this survey will be discussed. If determined feasible, a survey will be developed. Update: Fall 2022 meeting was postponed; meeting is being planned for Spring 2023.	Survey results compiled	Results published

Objective 6.1b: (Activity 7: Identify commercialization protocols at all 10 participating institutions) *[Change approved by NSF 2/9/22 and 5/10/22]*	Work with campuses to identify commercialization protocols with >50% protocols identified Y1 Annual Report: Commercialization protocols identified at 2 RUs, 1 MCU, and 3 PUIs, which equates to 6 of 10 participating institutions (60%). Y1 ACTUAL: No Change	100% protocols identified; Collaborative decision made regarding the handling joint IP and updated protocol document Y2 Annual Report: 4 of 4 TCUs surveyed. There are currently no IP protocols in place at the TCUs for invention IP. 2 TCUs (SBC and TMCC) are now working to develop these protocols. Y2 ACTUAL: Agendas, prepared for the annual campus visits, will include a discussion about these protocols and whether the campuses would like assistance.	Updated protocol document, and 1 invention disclosure Y3 Annual Report: Campus visits for Fall 2022 were postponed. Provisional patent application filed April 2022 on first invention disclosure.	Updated protocol document, 3+ invention disclosures, and 2+ provisional patents	Updated protocol document, 3+ invention disclosures, 2+ provisional patents, and 2+ patents

	Enroll participants in SHARPhub with 25% of CCBSE participants enrolled Y1 Annual Report: Five of 27 CCBSE researchers enrolled in SHARPhub = 19%. Y1 ACTUAL: No change	Continue to encourage CCBSE participants to enroll or take part in I-Corps activities, work with campuses to identify commercialization protocols and enroll participants in I-Corps Y2 Annual Report: Five of 28 CCBSE researchers enrolled in SHARPhub = 18%. Met with SHARPhub coordinator and learned that an I-Corps Hub will replace SHARPhub. As a result, the team has begun to examine the I-Corps training modules and will work with the CCBSE and Pillar Leads following the April EAB meeting to initiate next steps. Y2 ACTUAL: Mitigation plan was approved to change from SHARPhub to I-Corps. To ensure highest attendance, this kick-off will occur during the September 2022 All-Participants meeting.	Updated campus commercialization protocols, as necessary, continue to encourage CCBSE participants to enroll participants in I-Corps activities, and assistance with IP disclosures Y3 Annual Report: Following the 9/14/22 All-Participants meeting, the PI and co-PIs will meet with the CCBSE leads and the I-Corps trainer at UND to determine additional trainings for Y3 and to determine how CCBSE can be encouraged to enroll. NDSU is the lead for the NSF Great Plains I-Corps hub and are working on ways to partner.	Continued	Continued

Objective 6.1b: (Activity 8: Identify workshops / conferences to attend and mentoring opportunities (SHARPhub, I-Corps, USPTO Denver, SBIR, etc. *[Approved by NSF 5/10/22]*	Identify initial workshops related to typical processes for participants to discuss IP. Hold 1+ workshop or conference attended by >40% CCBSE participants Y1 Annual Report: Delayed due to COVID pandemic Y1 ACTUAL: 3 planned workshops	Continue to identify workshops related to typical processes for participants to discuss IP. Hold 1+ workshop or conference attended by >60% CCBSE participants Y2 Annual Report: Held 3 workshops and one conference panel session. Another panel session will be held at the April 2022 conference. Y2 ACTUAL: A brainstorming session at the September 2022 All-Participants meeting will identify which workshops are needed.	1+ workshop or conference attended by >75% CCBSE participants Y3 Annual Report: During the 9/14/22 All-Participants meeting, a 1-hour I-Corps workshop was held.	1+ workshop or conference attended by 75%+ CCBSE participants and 1 CCBSE workshop or conference attended by 80% CCBSE participants	1+ workshop or conference attended by 85%+ CCBSE participants and 1 CCBSE workshop or conference attended by 80% CCBSE participants
Objective 6.1b: (Activity 9: Based on other activities, determine potential funding possibilities with other SHARPhub EPSCoR states [KS, NE, OK, SD]) *[Approved by NSF 2/9/22 and 5/10/22]*		After Spring 2022 meeting with the SHARPhub coordinator and April 2022 EAB meeting, together with CCBSE and Pillar leads and the ND I-Corps coordinator/trainer explore potential conversations with other EPSCoR states participating in SHARPhub Y2 Annual Report: Met with SHARPhub/now I-Corps Hub facilitator to explore changes ahead of meeting with CCBSE and Pillar leads. Y2 ACTUAL: An approved mitigation plan changed from SHARPhub to I-Corps. PI/PD, PA, and EOD+C members will survey other EPSCoR states to	Begin conversations with other EPSCoR states with bioscience research agendas, including those that previously participated in SHARPhub Y3 Annual Report: Scheduled for Spring 2023. This process will also be coupled with travel RFPs that are issued for travel to other EPSCoR states.	Based on conversations with other EPSCoR states, determine and engage in action Items.	Engage in action items and determine sustainable potential of action items

		determine potential bioscience partners.			

Color Key:	Behind Schedule	On Track / In-Progress	Ahead of Schedule / Complete	N/A or Not yet started

TABLE 8. PROSPER: COMMUNICATION AND DISSEMINATION OUTPUT METRICS

PROSPER Element: Communication and Dissemination	Year 1 July 1, 2020-June 30, 2021	Year 2 July 1, 2021-June 30, 2022	Year 3 July 1, 2022-June 30, 2023	Year 4 July 1, 2023-June 30, 2024	Year 5 July 1, 2024-June 30, 2025
Objective 7.1a: Provide clear communication between all participants (Activity 1: Facilitate communication through regular meetings)	Meeting attendance Y1 Annual Report: Monthly Pillar, CCBSE and Management/ Leadership meetings. Bimonthly PROSPER meetings Y1 ACTUAL: No change	Meeting attendance Y2 Annual Report: Monthly Pillar, CCBSE and Management meetings; bi-monthly PROSPER meetings Y2 ACTUAL: attendance complete	Meeting attendance Y3 Annual Report: Required meetings are being scheduled, or have already been scheduled, for the year.	Meeting attendance	Meeting attendance
Objective 7.1a: (Activity 2: Facilitate communication across the by providing updates)	At least monthly outreach to participants, stakeholders, and citizens Y1 Annual Report: 7 newsletters (July 2020-January 2021) Y1 ACTUAL: 12 newsletters in Y1	At least monthly outreach to participants, stakeholders, and citizens Y2 Annual Report: 7 newsletters (July 2021-January 2022) Y2 ACTUAL: 12 newsletters in Y2	At least monthly outreach to participants, stakeholders, and citizens Y3 Annual Report: 7 newsletters (July 2022-January 2023)	At least monthly outreach to participants, stakeholders, and citizens	At least monthly outreach to participants, stakeholders, and citizens
Objective 7.1a: (Activity 3: Facilitate communication by providing internal communication training)	Training offered at least quarterly Y1 Annual Report: On track Y1 ACTUAL: 6 training sessions	Training offered at least quarterly Y2 Annual Report: 4 training sessions Y2 ACTUAL: 4 training sessions	Training offered at least quarterly Y3 Annual Report: Communications training:9/15/2022 Online Thought Leadership Training; 12/12/2022 Communicating Science training for dREU students; planned trainings on March 13th and March 28th, 2023	Training offered at least quarterly	Training offered at least quarterly

Objective 7.1b: Inform and educate stakeholders (Activity 1: Populate website and social media with relevant public-facing content)	Same metric framework for all: Baseline established of interaction (engagement rate) Y1 Annual Report: On track Y1 ACTUAL: baseline established	≥5% Increase in number of interactions per day divided by followers Y2 Annual Report: N/A until end of Y2 Y2 ACTUAL: ≥5% Increase	≥5% Increase in number of interactions per day divided by followers. Y3 Annual Report: Ongoing	Maintain engagement over the prior year. Maintain number of interactions per day divided by followers	Maintain engagement over the prior year. Maintain number of interactions per day divided by followers.
Objective 7.1b: (Activity 2: Assist team members from CCBSE and PROSPER with creating public-facing communication products)	*Needs research products; sessions begin in Y2*	5 sessions per year completed Y2 Annual Report: weekly drop-in training opportunities offered during Fall '21/Spring '22 Y2 ACTUAL: training offerings completed	5 sessions per year completed Y3 Annual Report: Science communication training completed as part of Fall 2022 dREU program; training schedule for 3/13 for all participants on how to communicate science, plus a communication training workshop for leadership (20-25 people) is scheduled for 3/28.	5 sessions per year completed	5 sessions per year completed
Objective 7.1b: (Activity 3: Disseminate project milestones and talking points to stakeholders and decision makers in the state)	2+ press releases Y1 Annual Report: On track Y1 ACTUAL: 3 press releases	4+ press releases; Updating stakeholders on project milestones (quarterly) Y2 Annual Report: 4 press releases Y2 ACTUAL: 4 press releases	4+ press releases; Updating stakeholders on project milestones (quarterly) Y3 Annual Report: Regularly updating stakeholders through Steering Committee meetings and highlights of ND-ACES activities and progress in the News and Notes, our newsletter which is distributed across the state.	4+ press releases; Updating stakeholders on project milestones (quarterly)	20 press releases over the 5-year period. Updating stakeholders on project milestones (quarterly)

Objective 7.1c: Contribute to a scientifically informed citizenry (Activity 1: Offer workshop opportunities for faculty and graduate students)	*2 workshops planned annually. Workshops begin Y2*	40+% attendance by ND-ACES participants Y2 Annual Report: poster design workshop planned mid-Spring '22; Alda Center workshop already completed; data for attendance % n/a until workshops are completed. Y2 ACTUAL: Workshops completed attendance - 42 at poster sessions. 19 at Alda sessions and 2 at EOD + C offerings.	55+% attendance by ND-ACES participants Y3 Annual Report: An online thought leadership training session was held A training is planned for 3/13 for all participants on how to communicate science, plus a communication training workshop for leadership (20-25 people) is scheduled for 3/28.	75+% attendance by ND-ACES participants	90% of ND-ACES participants will have attended at least 1 workshop over the 5-year period
Objective 7.1c: (Activity 2: Include public engagement opportunities as part of the annual conference)	Annual conference with attendees from each of the participating campuses. Y1 Annual Report: Conference is April 2021. Y1 ACTUAL: 1 annual conference, 10 of 10 participating institutions.	2022 Annual conference with attendees from each of the participating campuses Y2 Annual Report: Conference is April 2022. Y2 ACTUAL: 1 annual conference, all institutions with participants.	2023 Annual conference with attendees from each of the participating campuses. Y3 Annual Report: The Y3 annual conference is scheduled for 3/29/2023 in Fargo.	2024 Annual conference with attendees from each of the participating campuses	2025 Annual conference with attendees from each of the participating campuses.
Objective 7.1c: (Activity 3: Ensure that we have a diverse representation of science and scientists on website, to help engage all publics)		Scoring by external evaluation firm's diversity rubric Y2 Annual Report: discussed with The Mark in Y1/planned for Y2. Y2 ACTUAL: Analyzing The Mark's report.		Scoring by external evaluation firm's diversity rubric	
Objective 7.1c: (Activity 4: Engage with local publics about the value and the benefits of the science)	Science cafés planned annually. Science cafés begin Y2 Y1 Annual Report: On track Y1 ACTUAL: Although planned for Y2, 1 science café was held.	1-2 Science cafes supported Y2 Annual Report: planned, 1-2 in Fall '21 pending faculty availability 1 café held 10/26/2021, one café held March 2022. Y2 ACTUAL: 2 science cafes	2 Science cafés supported Y3 Annual Report: A science café was held March 2022. Working to schedule a science café Spring 2023.	2-3 Science cafés supported	2-3 Science cafés supported

Color Key:	Behind Schedule	On Track / In-Progress	Ahead of Schedule / Complete	N/A or Not yet started

TABLE 9. PROSPER: OVERALL METRICS

PROSPER Overall Milestone Metrics	Year 1 July 1, 2020-June 30, 2021	Year 2 July 1, 2021-June 30, 2022	Year 3 July 1, 2022-June 30, 2023	Year 4 July 1, 2023-June 30, 2024	Year 5 July 1, 2024-June 30, 2025
Meet annually with TCU presidents to report on the impacts of the collaboration efforts between CCBSE, PROSPER, and the TCUs. Report also on the numbers of American Indian students who are involved in ND-ACES programming	4 meetings/ year, one with each TCU president Y1 Annual Report: Not reported Y1 ACTUAL: Due to the COVID pandemic, these meetings were changed to a virtual format. Met with 4 TCU presidents during Summer/Fall 2020.	4 meetings, one with each TCU president Y2 Annual Report: Due to the COVID pandemic, one of these meetings was changed to a virtual format. Met with 4 of 4 TCU presidents during Summer/Fall 2021 Y2 ACTUAL: 4 meetings in Y2: 4 of 4 TCU presidents Summer/Fall 2021. Y3 planning is underway.	Projected: 4 meetings, one with each TCU president Y3 Annual Report: Planning for visits in late spring 2023.	Projected: 4 meetings, one with each TCU president	Projected: 4 meetings, one with each TCU president 5-YEAR TOTAL: 20 total meetings across the 5-year project Total to date: 8 meetings
Meet annually with MCU and PUI presidents to report on the impacts of the collaboration efforts between CCBSE, PROSPER and those campuses. Report also on the numbers of their students who are taking advantage of the programming	4 meeting/year, one with each MCU and PUI president Y1 Annual Report: Not reported Y1 ACTUAL: Due to the COVID pandemic, these meetings were changed to a virtual format. Met with PUI president during Summer/Fall 2020.	4 meetings - one with each MCU and PUI president Y2 Annual Report: Met in-person with 2 PUI presidents in July 2021 Y2 ACTUAL: In-person visits with 2 PUI presidents in Y2. Y3 planning is underway	Projected: 4 meetings - one with each MCU and PUI president Y3 Annual Report: Planning for visits in late spring 2023.	Projected: 4 meetings - one with each MCU and PUI president	Projected: 4 meetings - one with each MCU and PUI president 5-YEAR TOTAL: 20 total meetings across the 5-year project. Total to date: 3 meetings

Number of TCU visits (some of these visits will be virtual due to COVID-19)	4 visits - one visit at each TCU Y1 Annual Report: Not reported Y1 ACTUAL: Due to the COVID pandemic, these meetings were changed to a virtual format. Met with 4 of 4 TCUs Y1 during Summer/Fall 2020.	4 visits - one visit at each TCU Y2 Annual Report: Due to the COVID pandemic, one of these meetings was changed to a virtual format. Met with 4 TCUs Summer/ Fall 2021. Y2 ACTUAL: 9 visits in Y2 (one virtual): Fall 2021 - 5 of 5 TCUs; Spring 2022 - 4 TCUs.	Projected: 4 - one visit at each TCU Y3 Annual Report: Planning for visits in late spring 2023.	Projected: 4 - one visit at each TCU	Projected: 4 - one visit at each TCU 5-YEAR TOTAL: 20 total meetings across the 5-year project Total to date: 13 meetings
Number of MCU and PUI visits (some of these visits will be virtual due to COVID-19)	4 visits, one visit at each MCU and PUI Y1 Annual Report: Not reported Y1 ACTUAL: Due to COVID pandemic, met virtually with 1 MCU and 3 PUIs.	4 visits, one visit at each PUI and MCU Y2 Annual Report: Visits to 1 MCU and 3 PUIs Summer 2021. Y2 ACTUAL: 8 visits in Y2: Summer 2021 - 1 MCU, 3 of 3 PUIs, plus 1 PUI had another visit; May 2022 - 3 of 3 PUI visits. Y3 planning is underway.	Projected:4 one visit at each PUI and MCU Y3 Annual Report: Planning for visits in late spring 2023.	Projected:4 one visit at each PUI and MCU	Projected:4 one visit at each PUI and MCU 5-YEAR TOTAL: 20 total meetings across the 5-year project Total to date: 13 meetings
Number of legislator visits	2 visits Y1 Annual Report: not reported Y1 ACTUAL: 9 visits in Y1: 6 with ND legislators and 3 with congressional delegation	2 visits Y2 Annual Report: 17 visits (14 with ND legislators and 3 with congressional delegation) Y2 ACTUAL: 17 visits in Y2: 14 visits with ND legislators and 3 with congressional delegation	Projected: 2 visits Y3 Annual Report: 1 visit with a single ND legislator	Projected: 2 visits	Projected: 2 visits 5-YEAR TOTAL: 10 total visits across 5-year project Total to date: 26 visits

Color Key:	Behind Schedule	On Track / In-Progress	Ahead of Schedule / Complete	N/A or Not yet started