Biomedical Informatics Core Competencies

The AMIA Academic Forum appointed a special task force to develop a formal definition of **biomedical informatics** and to specify the core competencies that should drive curriculum and course design for graduate training in the field. A paper on this work is in preparation, but we present here the definition and core competencies that have been approved by the Academic Forum members. See also AMIA's page on the **Science of Informatics** (http://www.amia.org/about-amia/science-informatics).

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Definition of Biomedical Informatics

Biomedical informatics (BMI) is the interdisciplinary field that studies and pursues the effective uses of biomedical data, information, and knowledge for scientific inquiry, problem solving and decision making, motivated by efforts to improve human health.

Corollaries:

- BMI develops, studies and applies **theories, methods and processes** for the generation, storage, retrieval, use, and sharing of biomedical data, information, and knowledge.
- BMI builds on **computing, communication, and information sciences** and technologies and their application in biomedicine.
- BMI investigates and supports reasoning, modeling, simulation, experimentation and translation across the **spectrum from molecules to populations**, dealing with a variety of biological systems, bridging basic and clinical research and practice, and the healthcare enterprise.
- BMI, recognizing that people are the ultimate users of biomedical information, draws upon the **social and behavioral sciences** to inform the design and evaluation of technical solutions and the evolution of complex economic, ethical, social, educational, and organizational systems.

Core Competencies in Biomedical Informatics

Biomedical informatics (BMI) is the interdisciplinary, scientific field that studies and pursues the effective uses of biomedical data, information, and knowledge for scientific inquiry, problem solving and decision making, motivated by efforts to improve human health.

- **Acquire professional perspective**: *Summarize and explain the history and values of the discipline and its relationship to related fields while demonstrating an ability to read, interpret, and critique the core literature*
- **Analyze problems**: *Analyze, understand, abstract, and model a specific biomedical problem in terms of data, information and knowledge components*
- **Produce solutions**: *Use the problem analysis to identify and understand the space of possible solutions and generate designs that capture essential aspects of solutions and their components*
- **Articulate the rationale**: *Defend the specific solution and its advantage over competing options*
- **Implement, evaluate, and refine**: *Demonstrate an ability to carry out the solution, to assess its validity, and iteratively improve its design*
- **Innovate**: *Create new theories, typologies, frameworks, representations, methods, and processes to address biomedical and informatics problems*
- **Work collaboratively**: *Demonstrate the ability to team effectively with partners from diverse disciplines*
- **Disseminate and discuss**: *Communicate effectively to audiences in multiple disciplines in persuasive written and oral form*

BMI develops, studies and applies theories, methods and processes for the generation, storage, retrieval, use, and sharing of biomedical data, information, and knowledge.

All involve the ability to reason and relate to health information, concepts, and models spanning molecules to populations:

- **Theories:** *Understand and apply syntactic, semantic, cognitive, social, and pragmatic theories as they are used in biomedical informatics*
- **Typology:** *Explain and analyze the types and nature of biomedical data, information, and knowledge*
  - **Frameworks:** *Describe and apply the common conceptual frameworks that are used in*

biomedical informatics
  - *A framework is a modeling approach, programming approach, representational scheme, or an architectural design*
- **Representation:** *Understand and apply representations and models that are applicable to biomedical data, information, and knowledge*
  - *A representation is a method of using data structures or semantic elements in a computational environment*
- **Methods and processes:** *Recognize and apply the methods and processes used in different contexts of biomedical informatics*

BMI builds on computing, communication and information sciences and technologies and their application in biomedicine.

- **Prerequisite knowledge and skills:** *Assumes basic familiarity with data structures, algorithms, programming, mathematics, statistics*
- **Fundamental knowledge:** *Understand and gain experience applying the fundamentals of the field in the context of biomedical problems. For example:*
  - *Imaging and signal analysis*
  - *Information documentation, storage, and retrieval*
  - *Machine learning, including data mining*
  - *Networking, security, databases*
  - *NLP, semantic technologies*
  - *Representation of logical and probabilistic knowledge and reasoning*
  - *Simulation and modeling*
  - *Software engineering*
- **Procedural knowledge and skills:** *For substantive problems, understand and apply methods of inquiry and criteria for selecting and utilizing algorithms, techniques, and methods*
  - *Describe what is known about the application of the fundamentals within biomedicine*
  - *Identify the relevant existing approaches for a specific biomedical problem*
  - *Apply, adapt, and validate an existing approach to a specific biomedical problem*

BMI investigates and supports reasoning, modeling, simulation, experimentation, and translation across the spectrum from molecules to populations, dealing with a variety of biological systems, bridging basic and clinical research and practice, and the healthcare enterprise.

- **Prerequisite knowledge and skills:** *Basic familiarity with biological, biomedical, and population health concepts and problems including common research problems*
- **Fundamental knowledge:** *Understand the fundamentals of the field in the context of the effective use of biomedical data, information, and knowledge. For example:*
  - *Biology: molecule, sequence, protein, structure, function, cell, tissue, organ, organism, phenotype, populations*
  - *Translational and clinical research: genotype, phenotype, pathways, mechanisms, epigenetics, sample, protocol, study, subject, evidence, evaluation*
  - *Healthcare: screening, diagnosis (diagnoses, test results), prognosis, treatment (medications, procedures), prevention, billing, patient, consumer, provider, families, healthcare teams, quality assurance, safety, error reduction, comparative effectiveness, medical records, personal health records, information security and privacy*
  - *Population health: detection, prevention, screening, education, stratification, spatiotemporal patterns, ecologies of health, populations*
- **Procedural knowledge and skills:** *For substantive problems related to scientific inquiry, problem solving, and decision making, analyze and critically evaluate solutions based on biomedical informatics approaches*
  - *Frame complex biomedical informatics problems in terms of data, information, and knowledge*
  - *Analyze, select, apply, and evaluate biomedical informatics methods*
  - *Relate such knowledge to other problems within and across levels of the biomedical spectrum*

BMI, recognizing that people are the ultimate users of biomedical information, draws upon the social and behavioral sciences to inform the design and evaluation of technical solutions and the evolution of complex economic, ethical, social, educational, and organizational systems.

- **Prerequisite knowledge and skills:** *Familiarity with fundamentals of social, organizational, cognitive, and decision sciences*
- **Fundamental knowledge:**
  - *Design: human centered design, usability, human factors, cognitive and ergonomic engineering*
  - *Evaluation: controlled trials, observational studies, hypothesis testing, ethnographic methods, field observational methods*
  - *Social, behavioral and organizational sciences: Computer Support for Collaborative Work, Social Networks, change management*
  - *Ethical, Legal, Social Issues: human subjects, HIPAA, informed consent, secondary use of data, confidentiality, privacy*
  - *Economic, social and organizational context of biomedical research, pharmaceutical industry, medical instrumentation, healthcare, and public health*
- **Procedural knowledge and skills:** *Develop systems approaches to the solution of substantive problems in biomedical informatics*
  - *Frame complex biomedical informatics problems in terms of people, organizations and socio-technical systems*

- *Understand the challenges and limitations of technological solutions*
- *Design, implement, and validate the biomedical informatics applications and interventions*
- *Evaluate the impact of biomedical informatics applications and interventions in terms of people, organizations, and socio-technical systems*
- *Relate solutions to other problems within and across levels of the biomedical spectrum*