SESSION 7

Summary Discussion with Co-Moderators: Advancing Cancer Engineering

Co-Moderators

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Speakers

Session 1: Roderic Pettigrew and Rohit Bhargava
Session 2: Bruce Tromberg and Hedi Hricak
Session 3: Bissan Al-Lazikani and Hadiyah-Nicole Green
Session 4: Phillip Sharp and Christina Chapman
Session 5: Rohan Fernandes and Hadiyah-Nicole Green
Session 6: Roderic Pettigrew and Rohan Fernandes

SESSION 1

Overview of Cancer Engineering

KEY OBSERVATIONS IDENTIFIED BY SESSION SPEAKERS

- The time for Cancer Engineering has arrived
- Convergence offers potential for a third revolution in biomedicine, as impactful as molecular biology or genomics
- Driving concepts
  - Effective prevention, diagnosis and treatment
  - Bring high-quality cancer care to where people live
  - Context of cancer policy to ensure access and affordability
  - Engineering solutions for cancer control should encompass policy, infrastructure, and human behavior
- Precision cancer medicine is in competition with the instability of cancer
- Emerging technologies - Artificial intelligence, digital twins and virtual avatars, intelligent automation
  - Ethical and responsible use of technology
  - AI and radiomics has promising predictive potential
  - Clinical care and trials beyond walls
- Communication of scientific successes to society, bridge the gap between the communities and researchers.
- The “ZNA” challenge to Cancer Engineering: overcome zip code’s effect on cancer outcomes
- Convergence in education
  - Reimagine the training of the next generation, and reward team science
    - Integrating engineering into medicine and medicine into engineering, until boundaries vanish
  - Integrate the social sciences with the physical and computational sciences

SESSION 1

Overview of Cancer Engineering

ACTIONS TO PROMOTE CONVERGENCE IN ENGINEERING AND CANCER RESEARCH AND CARE

- **Reimagine the training** of the next generation in biomedical sciences and systems engineering, and reward team science.
- **Integrate the social sciences with the physical and computational sciences** Consider the "ZNA" (zip code's effect on genetics) and "Z-omics" (zip code's effect on genomics) of communities to ensure that progress in innovation is evenly distributed across populations.
- **Approach convergence in the context of cancer policy to ensure access** to cancer engineering innovations for all.
- **Leverage artificial intelligence**, digital technologies, intelligent automation, and tailored platforms to advance innovation in cancer research and care.
- **Improve the communication of scientific advancements** to bridge the gap between the communities and researchers.
- **Address the ethical and responsible use of artificial intelligence**.

SESSION 2

Engineering in Cancer Prevention and Diagnostics

KEY OBSERVATIONS IDENTIFIED BY SESSION SPEAKERS

- Cancer engineering has led to breakthroughs in oncology such as immunotherapy combinations, pancreatic cancer vaccines, and promising results from the PD-1 blockade rectal cancer clinical trial.
- Different types of cancer vaccine platforms, which have the potential to transform the cancer prevention and treatment paradigm, are in development.
- The RNA vaccine for pancreatic cancer shows promise as a treatment by activating tumor-specific immune cells.
- Computational analytics with routine imaging and data for precision diagnostics are essential for precision medicine, including prognosis, optimizing response to therapy, and improving patient outcomes.
- Artificial intelligence has the capacity to improve the identification of disease presence; predict outcomes, progression, and response to treatment; as well as improve precision medicine.
- To realize the full potential capabilities of artificial intelligence, it is essential for developers to be thoughtful and intentional in developing algorithms.
- Global collaborations have the potential to speed up the development and evaluation of new technologies.

SESSION 2

Engineering in Cancer Prevention and Diagnostics

ACTIONS TO PROMOTE CONVERGENCE IN ENGINEERING AND CANCER RESEARCH AND CARE

- Make technology development a core component of public health efforts to improve cancer prevention and early detection; develop strategies to drive uptake in all settings, ensure equity, and empower individuals and communities.
- A system approach is needed to improve cancer prevention and early detection and identify priority needs for new technologies.
- Be thoughtful and intentional in sharing data, building data repositories, and developing/validating algorithms: consider and reduce multiple bias sources: data collection/prep, model development/evaluation/deployment
- Develop multi-modal AI tools for cancer care; validate on completed and prospective clinical trials to establish performance, clinical value, and regulatory clearance; continue to optimize and validate post authorization.

SESSION 3

Engineering in Drug Development and Therapeutics

KEY OBSERVATIONS IDENTIFIED BY SESSION SPEAKERS

- Microdevices can test many different treatments at targeted tumor sites with minimal invasiveness.
- Nanoparticles have the potential to enable self-boosting vaccines, personalized cancer vaccines, and microneedle patch delivery.
- Many CAR T-cell therapies have now been approved, and large-scale manufacturing has been demonstrated.
- Natural killer cells for allogenic chimeric antigen receptor (CAR) therapy have the potential to provide many more patients with effective cell therapies at low cost.
- Engineering smart portable technologies have the potential to improve cancer care delivery at low-resource clinical centers.
- Cancer Vision Goggle has the potential to help surgeons ensure that no traces of tumors get left behind after cancer surgery.
- The concept of theranostics has the potential to lead to enhanced therapy efficacy, manageable adverse events, improved patient outcomes, and lower overall costs.
- The interplay of engineering technologies with artificial intelligence presents wide-ranging opportunities to advance cancer research and care.

SESSION 3

Engineering in Drug Development and Therapeutics

ACTIONS TO PROMOTE CONVERGENCE IN ENGINEERING AND CANCER RESEARCH AND CARE

- Address the challenges and opportunities to translate advances from engineering into technologies that enable precision cancer care and improve patient outcomes.
- Seek advice from the regulatory agencies early.
- Foster collaborations to help accelerate the discovery and development of cancer transformative breakthroughs for patients with cancer.
- Seek mentoring from more experienced investigators.
- Strategize for funding on the translational journey to include considering partnering with industry.

SESSION 4

From Cancer Biology to Engineering Solutions

KEY OBSERVATIONS IDENTIFIED BY SESSION SPEAKERS

- Integrated biomaterials approaches that enhance adoptively transferred T cell therapy with cancer vaccine technology have the potential to provide strong and long-lasting effects against solid tumors.
- Convergence of engineering with RNA innovation may radically change how drugs are developed and distributed.
- RNA therapeutics, combined with manufacturing advances, have the potential to enable hospital-based, personalized precision medicine that is more affordable and accessible.
- The mechanobiology field exemplifies the power of basic science in providing the foundation on which translational approaches may be built.

SESSION 4

From Cancer Biology to Engineering Solutions

ACTIONS TO PROMOTE CONVERGENCE IN ENGINEERING AND CANCER RESEARCH AND CARE

- A paradigm shift in drug development and distribution could increase innovation, accessibility, and affordability.
- Optimize and validate tumor neoantigen expression.
- Slowing or reversing immune aging by targeting thymus – type activity has the potential to produce a greater diversity of T cells, strengthening the immune system.
- Technology of mRNA cancer vaccines, combined with deployable manufacturing units, has the potential to facilitate hospital-based point-of-care treatment.
- Inhibiting cellular response to stiffness offers a potential therapeutic treatment of cancer.

SESSION 6

Cancer Engineering: Education

KEY OBSERVATIONS IDENTIFIED BY SESSION SPEAKERS

- Cancer engineering is a convergent exercise.
- Shared building spaces help to eliminate barriers, promote social connections, and collaboration among researchers and students.
- Shared funding opportunities facilitate collaboration across labs and institutions.
- Fellowships that encourage expansive studies in a variety of core areas provide a solid foundation in convergence.
- Technologies advance faster than we imagine – monitoring and integrating advances as we are aware of them keeps cancer engineering on the cutting edge.
- Collaborations between researchers from different institutions and disciplines help to foster innovations.

SESSION 6

Cancer Engineering: Education

ACTIONS TO PROMOTE CONVERGENCE IN ENGINEERING AND CANCER RESEARCH AND CARE

- Learn to communicate across fields and **connect to clinicians and patients**.
- Leverage constant structured and unstructured interactions to exchange ideas in an iterative fashion.
- Develop an educational pipeline to promote convergence, encourage hands-on learning, and bring the clinic to the curriculum.
- Invest in mentorship programs for early career scientists.
- Create academic departments and centers/institutions that facilitate the interface of cancer centers and basic science/engineering departments.
- Continuously provide funding to support and sustain collaborations that lead to cancer breakthroughs.