

Medical Physicist and the Scientific Mindset

Ehsan Samei

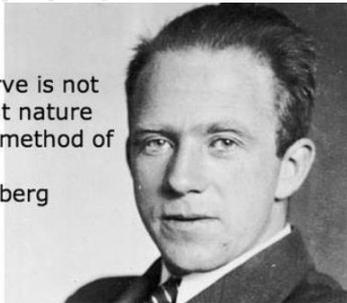
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Medical Physics and Science?

- Medical physics?
 - **Clinical application of physical sciences for the advancement of human health**
 - Applied physics towards clinical integration
- Science?
 - **Systematic, hypothesis driven inquiry that builds and organizes knowledge in the form of testable explanations and predictions**

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"What we observe is not nature itself, but nature exposed to our method of questioning."
-Werner Heisenberg



Is there reality beyond the observer?

- Every day experiences: **Truth: the absolute of "what things really are" exists independent of any observer.**
- Yet, truth remains illusive and out of our complete grasp, thus humility, and the perpetual derive towards understanding, creating, improving...

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How to be a scientist?

1. A foundational knowledge bank
2. Curiosity
3. Humble pursuit
4. Communication

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How to be a scientist?

1. A foundational knowledge bank
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3. **Humble pursuit**
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Signatures of humble pursuits

1. Unattainability
2. Imaginability
3. Concordance
4. Verifiability

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Signatures of pursuits: 1. Unattainability

- Reality is approachable, even progressively, yet not fully attainable.

If a scientific assertion is not characteristically verifiable by scientific inquiry (or equally deniable), such an assertion cannot belong to the realm of science.

Thomas Kuhn, Structure of Scientific Revolution

- Critical thinking

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Signatures of pursuits: 2. Imaginability

- Existential need for inspiration (from beyond)
- Formulation into hypotheses

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Signatures of pursuits: 3. Concordance

- Correspondence with norms

Under normal conditions the research scientist is not an innovator but a solver of puzzles, and the puzzles upon which he concentrates are just those which he believes can be both stated and solved within the existing scientific tradition.

Thomas Kuhn

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Signatures of pursuits: 4. Verifiability

- Collective wisdom and direct feedback to remedy the limitation of our reach towards objectivity
- The human safeguards towards objectivity

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Physics: Foundational science governing nature that can speak to:

1. Physical processes that inform health
Physics of Medicine
2. Technology to meet healthcare needs
Physics for Medicine
3. Practicing physical sciences in patient care
Physics in Medicine

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Medical physicist in...

- The clinic
- The academy
- The industry
- The government
- Research organizations
- Professional organizations

Multiple practice settings, one overarching foundation (science) and one overarching goal ...

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Advancing Human Health



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Opportunities in R&D



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Radiation therapy Adaptive radiation therapy Conformal radiation therapy Treatment planning optimization Machine learning for RT 4D-guided therapy Charged particle therapy New therapeutic mechanisms PET/SPECT-guided therapy MR-guided therapy Pre-clinical therapy and biology Radiation and immunotherapy Activation therapy	Health physics New dosimeters (n-fibers) Dose reduction methods Patient dose monitoring Organ dosimetry Neutron dosimetry Small animal dosimetry Charged-particle dosimetry Computational dosimetry	Medical imaging New contrast mechanisms New contrast agents Modulated beam imaging Performance Informatics Radiomics Radiogenomics Multi-D imaging Deep learning in imaging Compressed sensing Microscopy Functional MR and CT Spectral imaging
Nuclear medicine Monoclonal antibody img/trpy New nuclide therapies (As211) New PET agents (Ga68) Hybrid imaging (PET/SPECT/MR/CT) New reconstruction techniques Cerenkov imaging New detectors		

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Opportunities beyond radiation physics

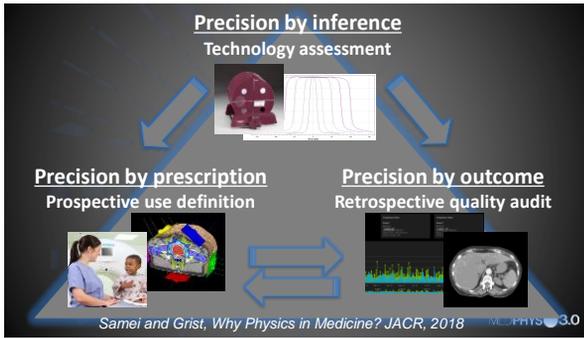
<u>Practices</u> Ophthalmology Dentistry Pathology Cardiology Surgery Urology Nephrology	<u>Approaches</u> Photonics Radio...mics Virtual reality Nano science Emerging medicine Multi-D optimization Bio-informatics and data science
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Opportunities in Clinics

Extending scholarship to clinical practice

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Conclusions and Practices

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- ## Conclusions
- Med Phys: a scientific discipline to the core
 - Effective healthcare needs engaged scientist medical physicists in *all* domains of the profession.
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Practices of a medical physics scientist

- Be the “scientist in the room”
- Focus on *evidential* effectiveness of care
- Be curious: *I wonder*
- Deploy critical thinking
- Build upon but advance the normative expectations

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Practices of a medical physics scientist

- Extend scholarship to clinical practice
 - Seek meaning beyond checklists, enthusiasm beyond duty
 - Devise pathways for translation of science to practice
 - Own the quantification of value in value-based care

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