

Example shown for a student interested in the Neurosciences; Electives will vary for different interests (e.g. in Cardiology, Cancer, Orthopedics etc). [Click here](#) for Elective Examples.

		YEAR 1			YEAR 2			YEAR 3			YEAR 4			É				
CREDIT	Core Princ. Med.	Integrative Sys. & Disease			PSYC 694			INSC 587			Frontiers in Aging			EP 815				
	Math. Med. Imaging	Math. Med. Imaging	2 Rotations		Acq. & Anal. Bio. Sig. II	BMB 581		BMB 616					1 Teaching Practicum					
		Biomed. Imag. Sci. Seminar					Radiology		Teaching Practicum									
	<div style="border: 1px solid red; display: inline-block; width: 15px; height: 10px; margin-right: 5px;"></div> Mandatory Courses																	
Thesis Research																		
					<ul style="list-style-type: none"> ★ Imaging Science Qualifying Exams ★ Binding with Reserach Advisor 								★ Dissertation Proposal Defense					
NON-CREDIT	Faculty Research Seminar		Neurosci. Neuroimag. Workshop		Shadowing/Clinical Management Conference			Neurosci. Neuroimag. Workshop		Research Survival Skills		Career Development Skills		Neurosci. Neuroimag. Workshop		Annual Neurosci. Neuroimag. Workshop		
	POR Cert.		Resp. Cond. of Research		Biomed. Imag. Sci. Retreat			Resp. Cond. of Research		Biomed. Imag. Sci. Retreat		Resp. Cond. of Research		Biomed. Imag. Sci. Retreat		Annual Biomed. Imag. Sci. Retreat		
	HIPPA														Annual Biomed. Career Fair			
													Annual Academic Review					
							Seminars											
	FALL	SPRING	SUMMER	FALL	SPRING	SUMMER	FALL	SPRING	SUMMER	FALL	SPRING	SUMMER	FALL	SPRING	SUMMER	É		

Elements of the PhD Program

HHMI-NIBIB Integrated Graduate Training Program in
Biomedical Imaging and Informational Sciences
University of Pennsylvania

I	Biomedical Sciences:	Core Principles of Medicine	Integrative Systems and Disease
II	Image Science:	Acquisition and Analysis of Biomedical Signals I & II	Mathematics of Medical Imaging and Measurements
III	Integrative:	Foundations of Radiology	Biomedical Image Sciences Seminar
IV	Professionalism:	<p>Training in Responsible Conduct of Research</p> <p>Patient Oriented Research Training</p>	<p>Teaching Practicum</p> <p>Research Survival Skills</p> <p>Career Development Skills</p>

Click on each component to see the course content.

Foundations of Biomedical Sciences : Core Principles of Medicine

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Developmental and Molecular Biology:	Genetics	Embryology
Cell Physiology and Matabolism:	Physiology	Biochemistry
Human Body Structure and Function:	Histology and Gross Anatomy	
Host Defense and Pharmacologic Responses:	Immunology	Microbiology

Taught by Medical School basic science and clinical faculty.


Go back 

Foundations of Biomedical Sciences : Integrative Systems and Disease

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- Mechanisms of Disease & Therapeutic Intervention
- Brain & Behavior
- Endocrinology
- GI & Nutrition
- Cardiology
- Pulmonary
- Dermatology
- Renal
- Infectious Diseases
- Reproduction


Taught by Medical School faculty.

Go back 

Foundations of Image Sciences : Math of Medical Imaging & Measurements

- Principles of analyses
- Fourier transform
- Interpolation & approximation of functions
- Sampling theory
- Digital filtering & noise analysis
- Direct observation of hospital
imaging equipment

Foundations of Image Sciences : Acquisition & Analysis of Biomedical Signals I & II


Go back 

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2-course sequence covering the fundamentals of data collection, signal processing, noise analysis, and quantitative image analysis for all emerging modalities in biological/materials imaging and in vivo imaging. Emphasis on cutting edge presented in an integrative interdisciplinary format with emphasis on clinical applications.

- Basic image processing and linear operators
- Pattern theory
- Segmentation
 - Edge detection, Bayesian framework, active snakes
 - Geodesic active contours and level sets
 - Active shape and appearance models
 - EM algorithms and Markov random field models
- Registration
 - Rigid and Affine methods
 - Deformable registration
 - Non-parametric approaches
- Human Brain Mapping
 - Structural morphometry
 - Functional analysis, statistical parametric mapping
- Developing image analysis applications w/the Insight Toolkit

Integrative : Foundations of Radiology

Go back 


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1. Introduction to Biomedical Imaging
2. X-Ray.
3. Ultrasound
4. MRI
5. PET and SPECT
6. Optical Imaging
7. Basic Principles of Image analysis
8. 3D visualization: MIP/Volume rendering
9. Approaches to Metabolic Imaging
10. Approaches to imaging Blood Flow/Perfusion
PET, DCE MRI, ASL, Ultrasound
11. Strategies for imaging receptors and molecular expression
12. Cell Tracking
13. Molecular biology for the Radiologist
14. Functional Cancer Imaging
15. Hot topics in Cardiovascular Imaging Research
16. Functional Neuro imaging
17. "DTI and Tractography"
18. Overview of Molecular imaging
19. Pulmonary functional imaging
20. MRI biomarkers of cartilage integrity
21. MRI as a means for predicting fracture risk
22. Overview of Radiology Patient Oriented Research and departmental resources:

23. What is a research protocol?
24. Overview of diagnostic Imaging Study Design
25. Statistics for imaging studies: Sensitivity, Specificity, PPV, NPV and ROC
26. What is GCP, GMP and GLP
27. The role of the IRB and the ethical conduct of Research
28. Quality control in research protocols
29. Design of Retrospective studies
30. Design of a treatment trial
31. Bias and its control
32. Imaging as a predictive biomarker
33. Designing and understanding a screening study
34. Outcomes and economic analysis applied to imaging studies
35. Overview of informatics issues related to imaging research
36. Academic Radiology Career Paths
37. Funding for clinically oriented

HHMI Trainees Program : Electives Example 1 :

NEUROSCIENCES Concentration


Next 

HHMI-NIBIB Integrated Graduate Training Program in
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Biomedical Image Science	<ul style="list-style-type: none"> • INSC 587 (Neurobiology of Disease); • PSYC 694 (Cognitive Neuroscience); • BMB 616 (Metabolic Pathways: Clinical Aspects of Energy Metabolism); • Frontier in Aging
Image Science Electives	<ul style="list-style-type: none"> • BMB 581 (Techniques of Magnetic Resonance Imaging)
Integrative Electives	<ul style="list-style-type: none"> • EP 815 (Clinical Trials and Translational Research)
Seminars	Over a dozen regular seminars and meetings are available, including the Center for Functional Neuroimaging Chalk Talks, the Institute for Research in Cognitive Science Brain and Language Series, the Center for Neurodegenerative Diseases Research seminar series
Other	Annual Neuroscience Neuroimaging Workshop; Annual Biomedical Image Sciences Retreat

HHMI Trainees Program : Electives Example 2 :

BREAST CANCER IMAGING Concentration

Previous 

HHMI-NIBIB Integrated Graduate Training Program in
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Biomedical Image Science	<ul style="list-style-type: none"> • CAMB 512 (Cancer Genetics and Biology); • PHRM 660 (Frontiers in Cancer Pharmacology); • BMIS6x1 (Anatomy, Histology and Radiology of the Breast) 	
Image Science Electives	<ul style="list-style-type: none"> • PHY 582 (Radiation Physics) • BMB 620 (Molecular Beacons) • Chem 700 (Biomolecular Imaging) 	
Integrative Electives	<ul style="list-style-type: none"> • BMIS6x2 (Small Animal Imaging) • BMIS6x3 (Biomedical Imaging Sciences Preceptorship) 	