Imaging Sciences Pathway Program

Part of a presentation at the 2009 ECEDHA meeting

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Motivation

- Imaging sciences are multi-disciplinary, requiring knowledge of biology, chemistry, physics, engineering, and applied mathematics.

- Washington University has many imaging resources and experts. It is nationally ranked in the top three of NIH funding for imaging sciences research.

- Imaging Sciences Pathway emphasizes biomaging for undergraduate students in engineering, the physical and life sciences.
Imaging Sciences Pathway Goals

• Educate “renaissance scientists” whose knowledge of the physical sciences, engineering, chemistry, and biology will allow them to explore new frontiers within the various and ever-expanding research domains of imaging sciences.

• Provide undergraduate students with extraordinary opportunities to carry out research with more than 60 leading investigators in the imaging sciences from more than 15 clinical and science departments.

• Provide undergraduate students in the physical and life sciences and engineering first-hand experience in this exciting area of biomedicine.
Consists of two parts:

- **An introductory freshman/sophomore seminar** introduces prospective Pathway students to the diverse imaging sciences research under way in Arts & Sciences, the School of Engineering & Applied Science, and the School of Medicine.

- **Courses for juniors and seniors** focus on chemistry, physics, computer science, engineering, and molecular cell biology as they relate to imaging sciences.
Core courses:

1) Seminar in Imaging Sciences (BIO 1810)

2) Introduction to Cell Biology (BIO 334)
   - Principles of Biology I (BIO 2960)
   - DNA Science: A Hands-On Workshop (BIO 280)
   - Biochemistry (BIO 4501/CHEM 456)

3) Principles & Applications of Biological Imaging (BIO 5146)

4) Contrast Agents for Biological Imaging (BIO/CHEM 5147)
   - Biological Imaging Technology (ESE 489/589/BME 494)

Students completing the ISP requirements receive a **Milestone** on their transcripts
ISP Undergraduate Research

- Students choose two faculty mentors from different disciplines (e.g., engineering and biology), with one being the primary mentor.

- Junior and senior Pathway students participate in an interdisciplinary imaging research project in the lab of the primary and/or secondary mentor.

- Students can receive credit for independent research.

- Students also participate in summer research internships between their junior and senior years; stipends are available through NIH R90 funds.
Facilities

The Pathway makes extensive use of the University’s vast imaging resources, which cover the full spectrum from molecular microscopy to full body human imaging.

- Mallinckrodt Neuroimaging Laboratories
- WU Small Animal Imaging Resource
- Cardiovascular Imaging Laboratory
- Molecular Imaging Center
- Center for Clinical Imaging Research
- Electronic Systems & Signals Research Laboratory
- High-Resolution NMR Facility
- High Throughput Screening Robotics Core
- Deep-Etch Electron Microscopy Facility
- Center for Biomedical and Bioorganic
- Mass Spectrometry
- Bakewell Neuroimaging Laboratory
### Imaging Sciences Pathway Plan

<table>
<thead>
<tr>
<th>Courses</th>
<th>Credits</th>
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<tbody>
<tr>
<td>CHEM 112A General Chemistry II</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 152 General Chemistry Lab.</td>
<td>2</td>
</tr>
<tr>
<td>BIO 1810 Seminar in Imaging Sciences</td>
<td>1</td>
</tr>
<tr>
<td>BIO 2960 Principles of Biology I</td>
<td>4</td>
</tr>
<tr>
<td>BIO 5146 Principles and Applications of Biological Imaging</td>
<td>3</td>
</tr>
<tr>
<td>ESE 489 Biological Imaging Technology</td>
<td>3</td>
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</tbody>
</table>

- Students participate in imaging research projects and can receive credits under ESE 497 Undergraduate Research.
- 16 total units required for ISP with pre-requisites.
- 20 available units in traditional curriculum consisting of free and breadth electives.
# BSEE Imaging Sciences Program

## Course Substitutions

<table>
<thead>
<tr>
<th>EE Curriculum Flexible Courses</th>
<th>Switch to</th>
<th>ISP Required + Prerequisite Courses</th>
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</thead>
</table>
| 9 units of Breadth Electives  | • 3 units CHEM 112A Gen. Chemistry 2  
• 2 units CHEM 152 Gen. Chemistry 2 Lab  
• 4 units BIO 2960 Principles of Biology 1 |
| 4 of 11 units of Free Electives | • 1 unit BIO 1810 Seminar In Imaging Sciences  
• 3 units BIO 5146 Principles and Applications of Biological Imaging |
| 3 of 15 units of EE Electives  | • 3 units ESE 489 Biological Imaging Technology |
|                               | Total Units | 16 |
|                               | • 3 units of ESE 497 Undergraduate Research on imaging research projects |
Example: ESE 489/589 Biological Imaging Technology
ESE 489/589 Biological Imaging Technology

• Course coordinators and modality experts:
  – J. A. O’Sullivan, ESE
  – J. P. Culver, Radiology
  – Y.-C. Tai, Radiology
  – J. Shimony, Radiology

Experts in EE, physics, biomedical physics, radiology.

• Textbook-based:

• Four lectures per modality:
  – Physics, mathematics, imaging
  – Lab tours and original literature critique

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<tr>
<th>Modalities</th>
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<tbody>
<tr>
<td>Fundamentals</td>
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<tr>
<td>Radiographic</td>
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<tr>
<td>Nuclear</td>
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<td>Optical</td>
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<tr>
<td>Ultrasound</td>
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<tr>
<td>Magnetic Resonance</td>
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</table>

Avanto 1.5 T MRI Scanner
Organ (e.g. CT, MRI, US)

Biological Tissue (e.g. Intrinsic optical imaging of cat visual cortex)

Cells (e.g. fluorescence microscopy)
Lab Tours

- State-of-the art CT and PET-CT imaging facilities
- **CCIR** Center for Clinical Imaging Research
- Siemens equipment

![SOMATOM Definition CT Scanner](image)

Biograph 64/40: PET-CT scanner

CT (anatomical image)

Fused PET-CT

PET (functional image)

Data (PETCT-165) from R. Laforest and M. Mintun, Radiology
• Contrasting state-of-the-art facilities with foundational papers

• Siemens equipment

W. C. Roentgen,
Nature, 1896
• Contrasting state-of-the-art facilities with foundational papers

• Siemens equipment

Biograph 64/40: PET-CT scanner

Design and Performance Characteristics of a Whole-Body Positron Transaxial Tomograph

Edward J. Hoffman, Michael S. Phelps, N. A. Mullani, Carol S. Higgins, and M. M. Ter-Pogossian
Washington University School of Medicine, St. Louis, Missouri

A whole-body positron-emission transaxial tomograph (PETT III) is described in detail and evaluated in terms of resolution, accuracy, and efficiency. The PETT III utilizes synchronously anticoincidence detection to provide spatial resolution; high sensitivity is achieved by using Na(TI) detectors set in a hexagonal array with a multiple-coincidence logic. The assumptions and approximations made in the reconstruction and their effect on image quality are discussed. Phantom studies show the depth-independent resolution and response of PETT III, as well as its ability to recover activity distribution quantitatively in the cross section measured. Images obtained with patients and normal volunteers show the potential clinical utility of PETT III.


Graph of PETT III. Coincidence circuitry and computer interface are contained in cabinet to right. Power supplies for stepping motors are in left cabinet. System computer is in adjacent room.

First PET machine, designed and built at Washington University in St. Louis

E. Hoffman, M. Phelps, N. A. Mullani, C. S. Higgins, and M. M. Ter-Pogossian

Instrumentations and Physics, 1976