Unique Aspects of
Regulating Research and Test Reactors

"Research Reactors Enable Scientific and Technological Innovation"

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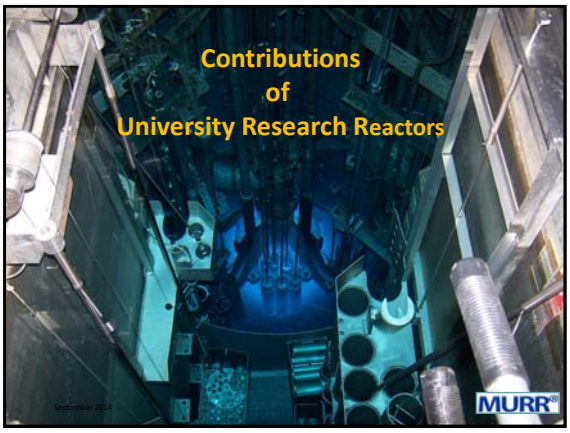
Atomic Energy Act

- A series of discoveries made in the late 1930s literally changed the history of the world. These discoveries led to the determination that enormous quantities of atomic energy could be made available by the bombardment of uranium by neutrons.
- At the close of World War II, the Federal Government created the Atomic Energy Commission (AEC) to control the peace-time uses of uranium and its fission products.
- The purpose AEA is to stimulate peace-time scientific research for the practical application of reactors for electric power generation and for the use of fission products for industrial and medical purposes.

U.S. University Research Reactors (25)

Facility	Power
University of Missouri-Columbia	10 MW
Massachusetts Institute of Technology	6 MW
University of California-Davis	2 MW
Rhode Island Nuclear Science Center	2 MW
Washington State University	1.3 MW
Kansas State University	1.25 MW
Oregon State University	1.1MW
University of Texas, Austin	1.1 MW
North Carolina State University	1.1 MW
Pennsylvania State University	1.1 MW
Texas A&M University	1.1 MW
University of Massachusetts-Lowell	1.1 MW
University of Wisconsin	1.1 MW

Facility	Power
Ohio State University	500 kW
Reed College	250 kW
University of California-Irvine	250 kW
University of Maryland	250 kW
University of Missouri-Rolla	200 kW
University of Florida	100 kW
University of Utah	100 kW
Purdue University	1 kW
Idaho State University	5 W
University of New Mexico	5 W
Texas A&M	5 W
Rensselaer Polytechnic Institute	1 W



University Research Reactors

- *Glenn Seaborg - May 1966:*

  "First, let me say that the usefulness of a research reactor depends primarily on the imagination and the drive of those who work with the reactor. Of course, they must have adequate financial support and the backing of the administration of the institution to which they are attached."

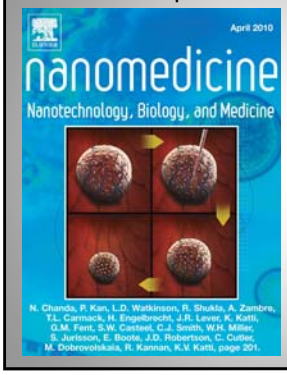
Providing a National Service

- TRTR facilities
  - Support the U.S. need for small batch or short-lived radioisotopes for medical, industrial, and research purposes.
  - Provide unique analytical services.
  - Provide unique research capabilities.
  - Provide unique educational and training opportunities to supply the next generation of scientists and engineers for the national laboratories, regulators, and industry.

Radioisotopes (Medical)

- Molybdenum-99/Technetium-99^{m} diagnostic – cardiac profusion, bone scans,
- Cesium-131 brachytherapy seeds to treat prostate cancer
- Iridium-192 brachytherapy seeds to treat solid tumors
- Lutetium-177 and Prometheum-149 for receptor-targeted radiopharmaceuticals (30 research/clinical trials)
- Phosphorus-32 and 33 biomedical radiotracers
- Selelium-75 biomedical radiotracers
- Samarium-153 for Quadramet™ for bone cancer pain palliation
- Ytrium-90 for Therapheres™ for inoperable liver cancer
- Strontium-89 for Metastron™ for bone cancer pain palliation
- Iodine-131 Thyroid cancer, diagnostic and therapy
- Iodine-125 biomedical tracer, imaging/therapy for prostate & brain cancers
- Xenon-133 for lung ventilation
- Gadolinium-159 and Holmium-166 for research in skeletal targeted radiopharmaceuticals
- Au-98 Gold nano-particles

Radiopharmaceutical Research



Radioactive Gold Nanoparticles in Cancer Therapy: Therapeutic Efficacy Studies of ^{198}AuNP-GA Nanoconstruct in Prostate Tumor Bearing Mice

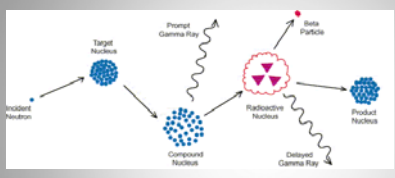
From the clinical editor : The findings of significant therapeutic efficacy, good in vivo tolerance and non-toxic features make these particles ideal candidates for future human applications.

Trace-Element Epidemiology

Selenium and Cancer

- Population, case-control and intervention trials have found a protective effect for selenium against some cancers.
- Evidence suggests that selenium supplementation several times greater than the average dietary intake are beneficial.
- The selenium protective effect appears to be more evident in males than females.
- Increased risks are observed when the toenail selenium concentration is less than ***0.75 ppm***.

Neutron Activation Analysis



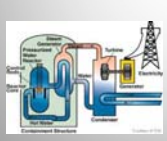
Commercial Applications

- Antimicrobial nanoparticles in human-use products
- Nutrients in pet food
- Development of new catalysts

Radioisotope (Industrial)

TRTR facilities provide support to process diagnostic and measurement service companies that in-turn support chemical and petroleum companies.

- Argon (^{41}Ar) as tracer for air, gas, and steam systems
- Bromine (^{82}Br) or Sodium (^{24}Na) to monitor liquid or solid process flow
- Sodium (^{24}Na) and Rubidium (^{86}Rb) as environmental tracers

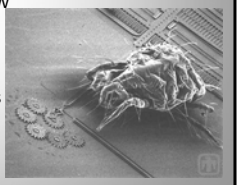


Radioisotope Micropower Sources

- Unattended sensors for intelligence and surveillance – 1-10 mW
- Microvalve - < 1 mW
- Acceleromter – 2-12 mW
- Motion/intruder detection – 2-12 mW
- Biomedical MEMS devices – 6-10 mW

Advantages of Nuclear Batteries

- High energy density
- Operate in extreme environments
- Long life (long half-life isotope)



Courtesy SNL, SUMMITTM Technologies, www.mems.sandia.gov

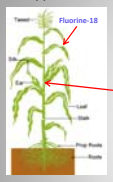
Material Sciences

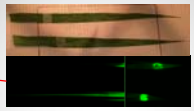
Semiconductors

- URR scientists pioneered the neutron transmutation doping (NTD) of silicon for the semiconductor industry.
  - using neutron irradiation to transmute silicon nuclei into phosphorus nuclei to supply material with the required uniform doping for these devices.
- NTD silicon is used to produce electronic devices that increase the efficiency of virtually any item that uses electrical power .
- Supplies the high-power diodes that are integral to today's hybrid automobiles.

Plant Science

Applications of nuclear science in agriculture to support "Global Food Security" programs - - -





Nuclear science helps scientists understand how t grow

Purpose - - -
Characterize all transporters that move sucrose throughout plants

Objective - - -
F-18 assays, in conjunction with genetic and molecular biological experiments will establish the biological roles of the different transporters

Preparing the Next Generation

- Introduction to Radiochemistry course at MU has more than 50 students enrolled this semester.
- Work force development – Department of Labor
- IAEA State Safeguards courses to train IAEA inspectors

Challenges for URRs

- From a high of 72 to the current 25, university research reactors are being shuttered by university administrators mostly as cost saving measures due to:
  - Lack of research funding
  - Lack of use by host institution faculty
  - Lack of maintenance/upgrade funding
  - Staffing issues
  - Increasing regulatory burden
  - Aging facilities
    - Penn State licensed in 1955 (License number R-002)
    - Many require upgrades to meet new and additional regulations even though no risk to the public