

CONTENTS

	Page
FOREWORD	III
NOTEWORTHY RECENT ADVANCEMENTS	IV
 RESEARCH IN THE MEDICAL AND LIFE SCIENCES	
RADIATION IN MEDICINE AND LIFE SCIENCES	3
Medical Research	3
Role of Trace Elements in Disease	3
Use of Manganese	3
Other Trace Elements	4
Analysis of Human Serum	4
Blood Studies	4
Use of Red Blood Cells in Inflammatory Diseases	4
Hypertransfusion Studies	5
Intraperitoneal Injections	6
Assay for Blood-forming Hormone	6
Iron Absorption	6
Platelet Production	7
Hibernation and Blood Counts	7
Liver Disease and Resistance to Infection	8
Radioisotopes in Metabolic Studies	9
ACRH Counter	9
Molybdenum Metabolism	9
Continuous Monitoring System for CO ₂	9
Iodine 131 Studies	10
Hormone Control of Bone Growth	11
Antibody Specificity	11
Cancer Research	12
Producing Cancer	13
Cancer-producing Conditions	13
Nucleic Acid in Leukemia	14
Protein Metabolism in Cancer	14
Unique Applications of Isotopes	14
Advances in Isotope Uses	14
Studies with Isotope Scanners	18
Liver scanning	18
Early detection of cancer spread	18
Low-level measurements	18
Antibody Therapy and Diagnosis	20
Chemically-induced tumors	20
Clinical trials in patients	20
Skin Test for Tumors	21
Teletherapy	21
Total Body Irradiation	21
Biochemical effects of irradiation	22
Radiation Sensitizers	22
Mercaptoethylamine	23
Synchrocyclotron Treatment of Acromegaly	23
Healing of Brain Tissue Irradiated with Alpha Particles	25
Somatic Effects of Radiation	25
Chronic Whole-Body Irradiation Effects	26
Mechanisms of Cancer Induction	26
Leukemia Virus	26
Breast Cancer	26
Models of Carcinogenesis	28

RADIATION IN MEDICINE—Continued

Somatic Effects of Radiation—Continued

	Page
Altered Susceptibility to Infections.....	28
Influenza Virus.....	28
Other Infections.....	28
Tetanus.....	29
Irradiation of the Circulating Blood.....	29
Radiation and Aging.....	30
Body Cell Mutation.....	30
Late Effects in Mice.....	30
Effects at 25 <i>r</i> and 500 <i>r</i>	31
Comparison with Aging Processes in Humans.....	31
Radiomimetic Chemicals.....	31
Repair Mechanisms.....	32
Recovery Rate vs. Amount of Injury.....	32
Effects on Gastrointestinal Tract.....	33
Damage in Dividing Cells.....	33
Effects on Hematopoietic System.....	35
Blood-forming Activity.....	35
Impairment of erythropoiesis.....	35
Increase in Fat.....	36
Effects on Reproductive System.....	36
Effect of Chronic Gamma Radiation in Rats and Mice.....	36
Developmental Abnormalities.....	37
In Vitro X-irradiation of the Mouse Egg.....	37
Irradiation of Germ Cells and Embryos.....	39
Organ Sensitivity.....	40
Effects on the Nervous System.....	41
Effects on Brain.....	41
Altered responses.....	41
High energy radiation from cyclotron.....	42
High energy radiation-accelerator.....	43
Cosmic ray effects.....	44
Functional changes.....	45
Studies with embryos.....	45
Effects on conditioning.....	46
Altered capability.....	46
Behavioral effects.....	47
Other Organ Systems.....	47
Effects on the Eye.....	48
Cataracts.....	48
General Physiology.....	48
Hibernation and Organ Regeneration.....	48
Toxicity of Radioelements and Chemicals.....	49
Radioelement Biological Effects.....	50
Five Year Study of Uranium Dust.....	50
Strontium Toxicity Studies.....	51
Yttrium 90 Ingestion.....	51
Neptunium Study.....	52
Retention of Cesium 137.....	52
Strontium 90 Behavior.....	52
Secretion in Milk.....	52
Iodine 131 Studies.....	52
Element State Elimination.....	53
Plutonium Studies.....	54
Clearance from the Lung.....	56
Measuring Techniques.....	56

RADIATION IN MEDICINE—Continued	
Toxicity of Radioelements and Chemicals—Continued	
	Page
Chemical Toxicity.....	58
Studies of Stable Rare Earths.....	58
Cerium and fat metabolism.....	58
Toxicity.....	58
Studies of Mercury Vapor.....	59
Early behavioral changes.....	59
Metabolism of mercury vapor.....	59
Physiological aspects.....	59
Radiation Genetics.....	60
Cytogenetics.....	60
Factors Affecting Chromosome Rearrangement.....	60
Vicia and Paramecium.....	60
Neurospora mold.....	61
Maize plant.....	62
Fruit fly genetics.....	62
Genetic Control and Radiation Response in Plant Tumors.....	62
Mammalian Cytogenetics.....	64
Studies of Primate Chromosomes.....	65
Cell-Culture Techniques for Space Biology.....	65
Hemoglobin Synthesis.....	65
Mutation Rate Analysis.....	65
Effects on Mice.....	66
Empirical measurements.....	66
Specific gene loci tests.....	66
Chromosome aberrations.....	66
Fertility.....	67
Mutator Genes.....	67
Induced Changes Within a Bacterial Gene.....	67
Microbial and Biochemical Genetics.....	68
Microbiology of Bacteria.....	68
Molecular and Cellular Level Studies.....	68
Contributions of Electron Microscopy.....	70
Mitochondrial Studies.....	70
Biochemistry.....	74
Effects of Ionizing Radiation on Thymine and Thymidine.....	74
DNA Synthesis Time.....	76
Cell Nucleus Function.....	78
RNA Studies.....	79
Biosynthesis.....	79
Constituents of RNA.....	79
Ribonucleic Acid Formation in Dividing Cells.....	79
Protein Synthesis.....	80
Cell-free system.....	80
Bioenergetics.....	80
Photosynthesis.....	80
Primary acts.....	80
Energy utilization.....	82
Physical Radiobiology.....	82
Ultraviolet studies.....	82
Mechanism of inactivation of enzymes by radiation.....	83
Electron-spin resonance studies.....	84
Nuclear magnetic resonance studies.....	84
Cell Physiology.....	84
Transfer of material across biological membranes.....	84
Bone structure and mechanism of bone formation.....	85
Role of surfactants lipids in cell function.....	85

RADIATION IN MEDICINE—Continued	Page
Health and Instrumentation.....	86
Health Physics.....	86
Proton Hazards in the Van Allen Belt.....	86
Radiation Dose to the Gastrointestinal Tract of Human Beings.....	86
Correlation Among Metals in the Body.....	87
Skeletal Burden of Plutonium in Man.....	88
Contamination Control.....	88
Radiological Physics.....	88
Absorbed Gamma Dose in Biological Specimens.....	89
Effect of Interface on Gamma Ray Dosimetry.....	91
Effects of Accelerator-Produced Neutrons.....	91
Neutron Dosimetry.....	92
Bragg Peak in Tissue.....	93
Absorption and Re-emission of Energy.....	93
Electron Interactions with Water Vapor.....	94
Luminescence in Biochemicals.....	94
Radiation Instruments.....	95
Assessment of Personnel Exposure Near Accelerators.....	95
Counting of Gamma Emitters.....	96
The Use of a Heterogeneous Phantom for Radiation Therapy.....	96
Lunar Surface Measurements.....	100
Semiconductor Detectors.....	100
Silicon surface-barrier detector.....	100
Lithium-compensated P-I-N detector.....	101
Beta Counter.....	101
Other Monitoring Devices.....	102
Radiation Protection and Treatment.....	103
Protective Agents.....	103
Dose Rate Effect.....	103
Tests to Evaluate Agents.....	103
Glycerol and Oxygen Effects on X-ray Sensitivity.....	104
Facilitation of Recovery.....	105
White Blood Cell Transplants.....	105
Physiology of Blood Platelets.....	106
Preservation Studies.....	106
Clinical trial.....	107
Study of Homologous Disease.....	107
Liver enlargement.....	107
Lymphoid cells.....	108
Suppressing reaction.....	110
Determining immunological function.....	110
Compatibility studies.....	112
Transplantation immunity test.....	112
Blood platelet compatibility.....	114
Removal of Radioactivity.....	116
Removal of Plutonium.....	116
Atmospheric Radioactivity and Fallout.....	116
Radioactivity in Soil, Food, and Man.....	116
Strontium 90 in Soil.....	116
Diet-Human Bone Strontium 90 Studies.....	117
Cesium 137 Levels in Milk and People.....	118
Cesium 137 Burdens in Nashville, Tenn.....	119
Ion Exchange for Removing Strontium from Milk.....	121
Gamma Ray Nuclides in Sewage.....	121

RADIATION IN MEDICINE—Continued	
Atmospheric Radioactivity and Fallout—Continued	Page
Stratospheric Debris Studies	121
Electrostatic Precipitator	121
Balloon-Borne Gamma Spectroscopy	123
Meteorology Studies at AEC Sites	124
Studies at Hanford	124
Fallout From Weapons Tests	126
Fallout Conference	126
Congressional Hearings on Fallout	126
 RESEARCH IN THE PHYSICAL SCIENCES	
TRANSPUTONIUM PROGRAM	129
Natural and Transmutation Elements	129
Transplutonium Element Research	131
Element Synthesis	132
Newest element	132
Element search	132
Isotope production	132
Fission and Decay Studies	133
Energy studies	134
Decay studies	134
Interaction study	134
Astrophysics	134
Actinide Elements	135
X-ray diffraction	135
Optical spectroscopy	135
Light absorption	135
Atomic Beam Studies	135
Element Isolation	136
Solvent systems	136
Ion exchange	136
Solid State Studies	136
Plutonium Metal	137
Production of Transplutonium Elements	137
Transmutation Process	137
Experimental Irradiation Program	138
Napkin rings	138
Increased hazards	140
Fuel rod used	140
New Argonne Facility	141
National Transplutonium Production Program	142
Production Program Plans	142
Production Method	142
New Facilities	143
High Flux Isotope Reactor	144
The Transuranium Processing Plant	146
Hazards	148
PHYSICS AND MATHEMATICS RESEARCH	149
High Energy Physics	149
Particle Research	149
Resonance Phenomena	151
Production of Elementary Particles	151
Discovery of Existence of Two Types of Neutrinos	153
Discovery of a New Anti-Hyperon	154

PHYSICS AND MATHEMATICS RESEARCH—Continued

High Energy Physics—Continued

	Page
Associated Particle Research.....	155
Discovery of the f^0 Elementary Particle.....	155
Search for the Dirac Monopole.....	156
Magnetic Moment of the Lambda Neutral (Λ^0) Particle.....	157
Coordination of Data.....	158
Inelastic Proton-Proton Scattering.....	158
Production of Mesons.....	160
K ⁻ Meson Research.....	160
Proton Helicity Experiment.....	160
Bubble Chamber Studies with Fast Neutrons.....	160
Spark Chambers.....	161
Parallel-plate Electrode Device.....	161
Muon Capture in Hydrogen.....	162
Rare Decay Mode Study.....	164
Sigma (Σ) and Lambda (Λ) Decay Studies.....	164
Lifetime and Decay Studies.....	164
Lifetime of the Neutral Pion.....	164
Lepton Decay of the Neutral Lambda Hyperon.....	166
Xenon Chamber Study of K-meson Decay.....	166
Low Energy Physics.....	166
Livermore Accelerator Program.....	166
U-235 Cross-Section.....	166
Photonuclear Cross-Sections.....	167
Nuclear Structure and Neutron Physics.....	167
Studies of Nuclear Structure.....	167
Neutron Pickup Reactions.....	167
Pickup and Stripping Reactions.....	168
Evidence for Axially Asymmetric Nuclei.....	168
Neutron Physics.....	168
Determination of the (n,p) Cross Section as a Function of Energy.....	168
Single Nuclear Particle Transfer Study.....	169
Atomic Beam Experiment.....	170
Parity Conservation.....	170
Measuring the Half-lives of Excited States of Nuclei.....	171
Nuclear Fission Studies.....	171
Fission Cross Section Measurements.....	171
Metallic Iron 57.....	172
Fission Energetics.....	172
Polarized Neutrons and Nuclei.....	173
Polarization of Fast Neutrons.....	173
Polarization of Neutrons Emitted from the T(d,n)He ⁴ Reaction.....	173
Polarized Photoneutrons.....	175
Neutron Diffraction Studies.....	175
Capture Cross Section of Tin Isotopes.....	176
Neutron Capture Gamma Rays.....	177
Neutron-induced Disintegration of Lithium.....	177
Applications of Mössbauer Effect.....	178
Electronic and Ground State Measurements.....	178
Studies on the (He ³ α) Reaction.....	178
Space Radiation Research.....	179
Van Allen Radiation.....	179
Piggyback flights.....	179
Space Equipment.....	179
ARENTS satellite neutron detector.....	179
MARINER electrostatic analyzer.....	180
Low-energy X-rays.....	180

PHYSICS AND MATHEMATICS RESEARCH—Continued	Page
Mathematics and Computer Research.....	180
New Equipment and Methods.....	180
IBM 7090 Computer-Significance Arithmetic.....	180
New High-Speed Magnetic Core Memory.....	180
Quadrupole Moment of the Deuteron.....	180
Computation of Wave Functions.....	181
Computation of Characteristic Roots of Matrices.....	181
Automatic Programming.....	181
Computer Proof of Mathematical Theorems.....	181
The Use of Computers in Experiments.....	183
Demonstration of Melting Phenomenon.....	183
Computing Planetary Orbits.....	183
CHEMISTRY RESEARCH.....	185
Chemical Properties and Reactions.....	185
Nuclear Chemistry.....	185
Important Isomer Polonium 212.....	185
Properties of Neutrons Emitted in Fission.....	187
Kinetic Energy Spectra of Fission Fragments.....	187
Theory of Chemical Kinetics.....	189
Reactions Induced by Complex Ions.....	189
Beta-ray Spectrometry Studies.....	190
Solar Neutrino Experiment.....	191
Studies of Short-Lived Fission Products.....	192
Longitudinal Polarization of Beta Particles.....	192
Physical and Inorganic Chemistry.....	194
Radiopolarography.....	194
Infrared Spectroscopy of Inorganic Structure Studies.....	194
New Activation Technique.....	195
Electrode Potentials of Oxide-Coated Metals.....	195
Low Temperature Calorimetry.....	196
Preparation of Xenon Tetrafluoride.....	197
Oxidation of Curium.....	197
Theoretical and Structural Chemistry.....	197
Study of High-Temperature Thermal Properties.....	197
Paramagnetic Resonance Absorption.....	197
Magnetic Susceptibility Studies.....	197
The Differential Method for Measuring Isotope Effects.....	198
Radiation Chemistry.....	200
Nature of Free Radicals from Irradiation of Water.....	200
Radiation Chemistry Studies at Notre Dame.....	200
Slow electrons.....	201
Parent-ion recapture.....	201
Dipole interaction.....	201
Negative ion significance.....	201
Nano-second measurements.....	201
Radiation Effects on Catalysts.....	202
High Temperature Chemistry.....	203
Densities of Complex Fluorides.....	203
Crystal-Structure Determinations.....	203
Solutions of Metals in Molten Salts.....	203
Chemistry of Liquid Metal Systems.....	203
Chemistry of Metal-Salt Systems at High Temperatures.....	204
Investigations of Fused Oxides and Glasses.....	204
Heavy Element Nuclear Chemistry.....	204
Interpretation of Nuclear Energy States.....	204

CHEMISTRY RESEARCH—Continued	Page
Systems and Materials Chemistry.....	205
Systems Studies.....	205
Chemistry of Ruthenium and Rhodium Oxides.....	205
New Compounds Containing Fluorine.....	205
Chemical Behavior of Solutes in Liquid Metals.....	206
Coordination Chemistry in Fused Salt Solutions.....	206
Phase Equilibria in High-Temperature Aqueous Systems.....	206
Phase Equilibria in Fused Salt Systems.....	207
Chemical Behavior of Uranium in Aqueous Solutions.....	207
Anion-Exchange Separation of Plutonium and Thorium.....	207
Isotope Separations.....	208
Foam Separation.....	208
Materials Studies.....	208
High Temperature Uranium Alloy Studies.....	208
Radiochemistry Applications to Geochemical Studies.....	209
Radiation Chemistry of High Polymers.....	209
Preparation of Fully Deuterated Compounds by Biosynthesis.....	209
METALLURGY AND MATERIALS.....	211
Production, Treatment, and Properties of Materials.....	211
Metallurgical Properties.....	211
Phase Equilibria and Thermodynamic Properties.....	211
Calorimetric Measurements on Metal Systems.....	211
A High Temperature Calorimeter.....	213
Metal Surface Studies.....	213
Brittle-Ductile Transition in Chromium.....	213
Electrorefining of Plutonium Metal.....	214
Metallurgy of Uranium and Its Alloys.....	214
Metallurgy of Plutonium.....	215
Metallurgy of Zirconium.....	215
Structure and Other Properties.....	217
Structure of the Delta-phase of Plutonium.....	217
A New Phase of Cerium Metal.....	217
Ceramic Reactions.....	217
Basic Research Studies in Ceramics.....	217
Preparation of Monocarbide Solid Solutions.....	217
Alloy Theory and the Nature of Solids.....	219
Kinetics of Dislocation Mechanisms.....	219
Electron Microscopy.....	219
Deformation Studies.....	219
Energies and Configurations of Clusters.....	220
Defect Controlled Processes in Metals and Alloys.....	220
Theory of Alloying of Zirconium.....	220
Solid Solubilities in Plutonium Alloys.....	221
Self Diffusion of Uranium.....	222
Chemistry of Graphite.....	222
Nuclear Magnetic Resonance in Metals and Alloys.....	222
Nuclear Magnetic Moment of Lithium 8.....	222
Magnetic Electron Density in Nickel Oxide.....	223
Superconductivity of Niobium.....	224
Physical Properties of Rare Earths.....	225
Interaction of Radiation with Materials.....	225
Theory Concerning Ranges of Energetic Atoms in Solids.....	225
Sputtering.....	225
Diffusion and Nucleation Enhanced by Radiation.....	226
Measurements of Diffusion of Fast-Neutron-Produced Defects.....	226
Thermal-Neutron Effects in Metals.....	226

METALLURGY AND MATERIALS—Continued	
Interaction of Radiation with Materials—Continued	Page
Neutron Damage on Nickel	227
X-Ray Studies of Irradiation Effects	227
Electron-Microscope Studies of Radiation Effects	228
Defects in Ionic Crystals	228
Investigation of Metal Surfaces	229
The Basic Mechanism of Radiation Damage	229
Radiation Effects in Crystalline Solids	229
Theoretical Studies of Radiation Effects	229
Self-irradiation Damage of Plutonium	230
CONTROLLED FUSION RESEARCH	233
Plasmas	233
Confinement	233
Progress	233
Controlled Fusion Devices	234
Stellarators	234
Self-Confinement and Fast-Compression Methods	234
The Levitron	234
The Scylla	237
The Pharos	237
Magnetic Mirror Machines	237
Toy Top Experiment	237
Table Top Experiment	238
ALICE Experiment	238
DCX-1 Experiment	240
DCX-2 Experiment	240
Cusped Geometries	240
The Mark II-B Picket Fence Experiment	242
The Mark III Picket Fence Experiment	242
The Astron Program	242
Rotating Plasma Investigations	242
Homopolar Devices	242
Supporting Research	242
Electron Cyclotron Heating	242
Plasma Physics	244
Cryogenic Coils	244
NUCLEAR REACTOR RESEARCH AND DEVELOPMENT	
RESEARCH IN REACTOR DEVELOPMENT	247
FUELS AND MATERIALS	248
Reactor Fuels	248
Irradiation Effects	248
Swelling of Irradiated Uranium	248
Group "a"	248
Groups "c" and "d"	248
Distortion	249
Swelling	249
Uranium Dioxide High Burnup Program	251
Basic and Special Fuel Program	251
Heat Transfer Studies for Uranium Dioxide	252
High Temperature Stability of Irradiated UO ₂	254
Evaluation of Irradiated Microstructures	255
Irradiation Testing	255
Coated Particle Fuel Materials	257
Pebble-bed fuel	258
Plutonium Ceramics Research	259
Capsule irradiation tests	259

FUELS AND MATERIALS—Continued		Page
Reactor Fuels—Continued		261
Thorium Fuel-Cycle Development.....		262
Sol-Gel Process.....		262
Vibratory Compaction.....		262
Irradiation Testing.....		263
Physical Properties of ThO ₂ -UO ₂ Solid Solutions.....		263
Studies of Other Materials.....		263
Radiation Effects on Stress-Rupture Life.....		263
In-Reactor Measurements of Mechanical Properties.....		263
In-reactor creep tests.....		264
Irradiation and Environmental Effects in Structural Materials.....		264
Pre-irradiation activities.....		265
Nuclear Radiation Effects on Steel.....		266
High Temperature Properties of BeO.....		267
Joining of Ceramic Materials by Brazing.....		267
Control-Rod Development.....		267
Europium oxide studies.....		269
Boron-gradient neutron absorbers.....		270
COMPONENT DEVELOPMENT.....		270
Instrumentation.....		270
Reactor Control System Development.....		270
Automatic Control System.....		270
Flux Measurer.....		270
High-Range Temperature Sensor.....		271
Heat Transfer, Fluid Dynamics, and Coolant Technology.....		271
Liquid Metal Heat Transfer.....		272
Swirl-Flow Boiling Technique.....		273
Boiling Potassium Fluid Dynamics.....		273
Effects of Thermal Transients on Structural Materials.....		275
REACTOR PHYSICS.....		275
Neutron Utilization.....		275
Integral Neutron Thermalization.....		275
Measurement of Protactinium 233.....		278
Neutron Cross Section Calculations.....		278
RPI Linear Electron Accelerator.....		280
Inelastic Scattering Measurements.....		280
Physics of D ₂ O Reactor Lattices.....		281
UO ₂ and Uranium Metal Exponential Experiments.....		281
Spectral Shift Physics Studies.....		282
Fast Flux Monitors.....		282
Basic Data.....		282
Tritium from Fission.....		282
Reactor Shielding Evaluation.....		283
Reactor Calculations.....		283
Direct Conversion.....		283
Thermionic Method.....		283
Plasma diode.....		234
Reactor study.....		284
Regenerative emf cell.....		285
Thermoelectric Method.....		285

	Page
REACTOR SAFETY.....	287
Reactor Kinetics.....	287
The SPERT Program.....	287
Current Experiments.....	287
SPERT 1.....	287
SPERT 2.....	290
SPERT 3.....	290
SPERT 4.....	290
Other Reactor Kinetics Research.....	290
Fast Reactor Safety Studies.....	290
Flow Instability Studies.....	292
Hazardous Chemical Reactions.....	292
Fission Product Release.....	292
Fuel overheating.....	292
Fission product aerosols.....	292
Fuel vaporization.....	294
Uranium-iodine compound.....	294
Diffusion through cladding.....	294
Supporting Activities in Safety Research.....	295
Removal of Radioactive Particulate Matter.....	295
Removal of Iodine Vapor.....	295
Safety Test Engineering Program.....	295
Reactor Containment.....	296
Pressure load studies.....	296
Energy absorption.....	296
Stress and strain.....	296
Loss of coolant.....	297
CHEMICAL PROCESS DEVELOPMENT.....	298
Recovery of Fertile Material.....	298
Aqueous Head-End Treatments for Metal-Clad Fuels.....	298
Total Dissolution of the Fuel and Its Cladding.....	298
Electrolytic Dissolution of Metallic Fuels.....	300
Continuous Dissolution of Zirconium Fuel.....	300
Selective Removal of the Cladding by Dissolution.....	300
Selective Removal by the De jacketing and Chop-Leach Method.....	302
Fuels Dispersed in Graphite.....	303
The grind-leach process.....	303
The combustion-dissolution process.....	303
The direct-leach process.....	303
Pyrometallurgical and Volatility-Fluidization Process.....	304
Pyrometallurgical Processes.....	304
Melt-refining process.....	304
Processes Employing Liquid Metal Solvents.....	305
Preparation of Compounds in Liquid Metal Media.....	305
Fluoride Volatility Processes.....	305
Ceramic fuels.....	306
Fused Salt-Fluoride Volatility Process.....	307
Zirconium-matrix fuels.....	308
Chlorine volatilization.....	309
Supporting Research.....	309
Direct Air Pulsing System for Pulse Column Application.....	309

RESEARCH ON RADIATION IN THE ENVIRONMENT

	Page
ENVIRONMENTAL RADIATION STUDIES.....	313
Project Chariot Environmental Studies.....	313
Oak Ridge Area Studies.....	314
Fresh Water Life Systems.....	314
Radiation Effects on Aquatic Populations.....	314
Radioisotopes in Insect Ecology.....	315
Biological Indicators of Strontium 90.....	316
Water Transport of Radionuclides.....	317
White Oak Creek Drainage Basin Study.....	318
Geological formations.....	318
Water movements.....	318
Sampling results.....	318
Sediment movement.....	320
Clinch and Tennessee Rivers Studies.....	320
Dilution and dispersion.....	320
Concentrations in river water.....	321
Sediment studies.....	321
Plant and Animal Systems.....	322
Radiation Effects on a Natural Microflora.....	323
X-Ray Tolerance of Two Species of Flour Beetles.....	324
Soil-Plant Relationships.....	324
Beryllium Studies.....	324
Strontium Uptake and Reduced Water Supply.....	324
Ion Absorption Through Roots.....	326
Sulfate Movement.....	326
Ecological Recovery of Devastated Landscapes.....	326
Fresh Water Systems.....	327
Chemical Methods.....	327
Strontium Metabolism.....	327
Hydraulic Test Flume.....	327
Marine Sciences.....	328
Biological Studies.....	328
Effects of Radiation on Sea Urchin Eggs.....	328
Radioactive Zinc.....	329
Studies of Fisheries.....	329
Concentration of Suspended Radioactive Wastes into Bottom Deposits.....	330
Radiochemical Studies.....	330
Marine Mineralogy.....	330
Tracing Nearshore Sediment Movement.....	331
Radiocarbon Measurements in the Pacific Ocean.....	333
Radiocarbon Studies of Deep Ocean Currents.....	335
Age Determination in Sediments.....	335
Radium Distribution in Sea Water.....	335
Distributions of Fallout Radioisotopes.....	336
Strontium movement.....	336
Vertical mixing.....	337
Organic reduction of cerium.....	337
Other Marine Isotopic Studies.....	337
Distribution of cesium 137 in oceans.....	338
Lead 210 in natural waters.....	338
Iron 55.....	338
Ionium/thorium geochronologies.....	339
Cosmic-ray produced silicon 32 in nature.....	339

ENVIRONMENTAL RADIATION STUDIES—Continued

	Page
Marine Sciences—Continued	
Physical Studies.....	339
Water Circulation and Quality of Humboldt Bay.....	339
Studies of Sediments in Bogue Sound, N.C.....	340
Columbia River Effects in the Northeast Pacific.....	341
Deep water studies.....	341
Plume distribution.....	344
Geologic and Hydrologic Studies.....	346
Studies at Commission Sites.....	346
Liquid Waste Disposal to Ground.....	346
Geologic-hydrologic studies at Hanford.....	347
Studies at NRTS.....	348
Studies in Soil Physics.....	348
Studies in Soil Mineralogy.....	349
Selective adsorption.....	350
Strontium removal.....	352
TREATMENT AND DISPOSAL OF RADIOACTIVE WASTES	
WASTE TREATMENT AND DISPOSAL.....	355
Treatment of Low-Level Wastes.....	355
Chemical Scavenging.....	355
Resin Treatment.....	355
Disposal in Geologic Formations.....	355
Disposal in Natural Salt Formations.....	355
Kansas Experiment.....	355
Disposal by Hydrofracturing.....	356
Grout-Fracture Method.....	356
Disposal in Permeable Rock Formations.....	357
Joint Program.....	358
Disposal in Impermeable Rock Formations.....	358
Savannah River Facility.....	358
Protection for Buried Waste.....	359
Leaching Prevention.....	359
Other Studies.....	361
Evaluations of Waste-Disposal Methods.....	361
Sulfur for Waste Treatment and Storage.....	361
Gaseous and Aerosol Effluent Studies.....	362

APPENDICES

1. Major Research and Development Installations of the U.S. Atomic Energy Commission.....	365
2. Current Commission Research Contracts in the Biological and Medical Sciences.....	369
3. Current Commission Research Contracts in Physical Sciences.....	388
4. Current Commission Research Contracts in Reactor Development and Waste Management.....	403