

Radioactive Isotopes Used in Medical Diagnosis and Therapy

<i>Name and Symbol</i>	<i>Principal Nuclear Properties</i>	<i>Form</i>	<i>Use</i>
Americium ²⁴¹ Am	Half-life 432.7y α (5.49, 5.44) γ (0.060)	Encapsulated source	Diagnostic: External radiation source for bone mineral analyzer
			Therapeutic: Antineoplastic (intracavitary radiation source)
Calcium ⁴⁷ Ca	Half-life 4.53d β^- (0.67, 1.98) γ (1.297)	Calcium chloride	Diagnostic: Calcium metabolism studies
Cesium ¹³⁷ Cs	Half-life 30.0y β^- (1.176, 0.514)	Cesium chloride or cesium sulfate (encased in needles or applicator cells)	Therapeutic: Antineoplastic (teletherapy source, intracavitary or interstitial radiation source)
Daughter ^{137m} Ba	Half-life 2.552min γ (0.662)		
Californium ²⁵² Cf	Half-life 2.645y α (6.217)	Sealed source	Therapeutic: Antineoplastic (intracavitary or interstitial radiation source)
Chromium ⁵¹ Cr	Half-life 27.704d K; γ (0.32)	Chromic chloride	Diagnostic: Determination of serum protein loss into the gastrointestinal tract
		Chromium disodium edetate	Diagnostic: Determination of glomerular filtration rate
		Labeled human serum albumin	Diagnostic: Placenta localization; gastrointestinal protein loss
		Sodium chromate labeled red blood cells	Diagnostic: Determination of red cell volume or mass; red cell survival time; evaluation of blood loss; spleen imaging; placenta localization
Cobalt ⁶⁰ Co	Half-life 5.271y β^- (0.318, 1.48) γ (1.173, 1.332)	Metallic cobalt	Therapeutic: Antineoplastic (teletherapy source, intracavitary or interstitial radiation source)
		Radioactive vitamin B ₁₂	Diagnostic: In Schilling test for absence of intrinsic factor (pernicious anemia) or other defects of intestinal vitamin B ₁₂ absorption
⁵⁷ Co	Half-life 271.77d K; γ (0.122)	Radioactive vitamin B ₁₂	Diagnostic: In Schilling test for absence of intrinsic factor (pernicious anemia) or other defects of intestinal vitamin B ₁₂ absorption
⁵⁸ Co	Half-life 71.91d K; β^+ (0.48) γ (0.811)	Radioactive vitamin B ₁₂	Diagnostic: In Schilling test for absence of intrinsic factor (pernicious anemia) or other defects of intestinal vitamin B ₁₂ absorption
Copper ⁶⁴ Cu	Half-life 12.701h β^- (0.571), β^+ (0.657), γ (1.34)	Copper versenate	Diagnostic: Brain scan
		Copper acetate	Diagnostic: Study of Wilson's disease
Fluorine ¹⁸ F	Half-life 1.8295h β^+ (0.635)	Fludeoxyglucose (FDG)	Diagnostic: Functional brain imaging
		Sodium fluoride (reactor produced)	Diagnostic: Bone scan
Gadolinium ¹⁵³ Gd	Half-life 241.6d K; γ (0.70, 0.097, 0.103)	Sealed source	Diagnostic: External radiation source for bone mineral analyzer
Gallium ⁶⁷ Ga	Half-life 3.261d K; γ (0.093, 0.184, 0.300, 0.393)	Gallium citrate	Diagnostic: Detection of neoplastic and inflammatory lesions; tumor seeking agent
Gold ¹⁹⁸ Au	Half-life 2.6935d β^- (1.371, 0.962) γ (0.412)	Colloidal gold	Diagnostic: Liver imaging
		Colloidal gold or seeds	Therapeutic: Antineoplastic (radiation source) in treatment of widespread abdominal carcinomatosis with ascites; carcinomatosis of pleura with effusion; lymphomas; interstitially in metastatic tumors

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Indium 113mIn	Half-life 1.658h $\gamma(0.393)$	Indium colloid	Diagnostic: Liver and spleen imaging	
		Indium Fe(OH) ₃	Diagnostic: Pulmonary perfusion imaging; cardiac output	
		Indium labeled red blood cells	Diagnostic: Determn of blood volume	
		Indium pentetate (DTPA)	Diagnostic: Brain scan; renal function studies	
		Indium transferrin	Diagnostic: Static cardiovascular blood pool imaging; hepatic and placenta blood pool imaging; placenta localization	
	111In	Half-life 2.807d K; $\gamma(0.172, 0.247)$	Indium bleomycin	Diagnostic: Tumor detection
			Indium capromab pendetide	Diagnostic: Tumor detection for prostate cancer
			Indium chloride	Diagnostic: Hematopoietic bone marrow imaging; tumor detection
			Indium oxyquinoline (oxine) labeled leukocytes	Diagnostic: Detection of abscesses, infections and inflammation
			Indium oxyquinoline (oxine) labeled platelets	Diagnostic: Detection of deep vein thrombosis; cardiac thrombosis; renal transplant rejection
Indium oxyquinoline (oxine) labeled red blood cells			Diagnostic: Detection of gastrointestinal bleeding	
Indium pentetate (DTPA)			Diagnostic: Gastric emptying studies; cardiac output; renal scintigraphy; cisternography	
Indium pentetreotide			Diagnostic: Neuroendocrine tumor detection	
Indium satumomab pendetide			Diagnostic: Tumor detection	
Iodine 131I	Half-life 8.040d $\beta^- (0.607, 0.81, 0.336)$ $\gamma(0.080, 0.284, 0.364, 0.637, 0.723)$	Diiodofluorescein	Diagnostic: Brain scan	
		Iobenguane (MIBG)	Diagnostic: Adrenomedullary imaging and tumor detection	
			Therapeutic: Antineoplastic (radiation source) in treatment of neuroendocrine tumors	
		Iodinated fats and fatty acids, e.g. oleic acid, triolein	Diagnostic: Pancreatic function; intestinal fat absorption	
		Iodinated fibrinogen	Diagnostic: <i>In vitro</i> determn of fibrinolytic enzymes	
		Iodinated human serum albumin (IHSA)	Diagnostic: Plasma volume determn; peripheral vascular flow; cardiac output; circulation time; cerebral vascular flow. Brain scan; placenta localization. Cisternography	
		Iodinated human serum albumin (macroaggregated)	Diagnostic: Pulmonary perfusion imaging	
		Iodinated human serum albumin (microaggregated)	Diagnostic: Hepatic blood pool imaging	
		Iodinated levothyroxine	Diagnostic: Metabolic study of endogenous thyroxine. <i>In vitro</i> determn of thyroid function	
		Iodinated liothyronine	Diagnostic: <i>In vitro</i> determn of thyroid function	
		Iodinated povidone	Diagnostic: Protein-loss enteropathy	
		Iodinated rose bengal	Diagnostic: Liver function in hepatic excretion studies	
		Iodinated tositumomab	Therapeutic: Antineoplastic (radiation source) in treatment of non-Hodgkin's lymphoma	
		Iodohippurate sodium	Diagnostic: Determn of renal function, renal blood flow, urinary tract obstruction; renal imaging	
		Sodium iodide	Diagnostic: Thyroid function studies; thyroid imaging	
			Therapeutic: Hyperthyroidism; antineoplastic (radiation source) in treatment of thyroid cancer	

Radioactive Isotopes Used in Medical Diagnosis and Therapy (Continued)

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Iodine ¹²⁵ I	Half-life 60.14d K; γ (0.035)	Iodinated fats and fatty acids	Diagnostic: Pancreatic function; intestinal fat absorption
		Iodinated fibrinogen	Diagnostic: Localization of deep vein thrombosis; study of fibrinogen metabolism. <i>In vitro</i> determin of fibrinolytic enzymes
		Iodinated human serum albumin (IHSA)	Diagnostic: Determin of blood or plasma volume; circulation time; cardiac output
		Iodinated levothyroxine	Diagnostic: Metabolic study of endogenous thyroxine. <i>In vitro</i> determin of thyroid function
		Iodinated liothyronine	Diagnostic: <i>In vitro</i> determin of thyroid function
		Iodinated povidone	Diagnostic: Protein-loss enteropathy
		Iodinated rose bengal	Diagnostic: Liver function in hepatic excretion studies
		Sealed source	Diagnostic: External radiation source for bone mineral analyzer
		Sodium iodide	Diagnostic: Thyroid function studies; thyroid imaging
¹²³ I	Half-life 13.2h K; γ (0.159)	IACFT	Diagnostic: SPECT cerebral imaging
		Iobenguane (MIBG)	Diagnostic: Adrenomedullary imaging and tumor detection
			Therapeutic: Antineoplastic (radiation source) in treatment of neuroendocrine tumors
		Iodohippurate sodium	Diagnostic: Determin of renal function, renal blood flow, urinary obstruction; renal imaging
		Iofetamine hydrochloride (IMP)	Diagnostic: Cerebral imaging
		Ioflupane (I-FP-CIT)	Diagnostic: SPECT cerebral imaging
		Sodium iodide	Diagnostic: Thyroid function studies; thyroid imaging
Iridium ¹⁹² Ir	Half-life 73.831d β^- (0.67) γ (0.296, 0.308, 0.317, 0.468, 0.589, 0.604, 0.612)	Seed encased in nylon ribbon	Therapeutic: Antineoplastic (interstitial radiation source)
Iron ⁵⁹ Fe	Half-life 44.496d β^- (0.273, 0.475) γ (1.095, 1.292)	Ferric chloride Ferrous citrate Ferrous sulfate	Diagnostic: Ferrokinetics
		Labeled red blood cells	Diagnostic: Red cell maturation studies
⁵⁵ Fe	Half-life 2.73y K	Labeled red blood cells	Diagnostic: Red cell maturation studies
Krypton ⁸⁵ Kr	Half-life 10.72y β^- (0.67) γ (0.517)	Gas	Diagnostic: Cardiac abnormalities; skeletal muscle, coronary or cerebral blood flow
		^{81m} Kr	Half-life 13s γ (0.19)
Lead RaD(²¹⁰ Pb)	Half-life 22.3y β^- (0.017) γ (0.047)	Beta ray applicator	Therapeutic: See Strontium (⁹⁰ Sr)
Daughter RaE(²¹⁰ Bi)	Half-life 5.013d β^- (1.16)		
Mercury ¹⁹⁷ Hg	Half-life 2.6725d K; γ (0.077)	Chlomerodrin	Diagnostic: Brain scan; renal imaging
		Merisoprol	Diagnostic: Determin of renal function

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<i>Name and Symbol</i>	<i>Principal Nuclear Properties</i>	<i>Form</i>	<i>Use</i>
Mercury ²⁰³ Hg	Half-life 46.60d β^- (0.214) γ (0.279)	Chlormerodrin	Diagnostic: Brain scan; renal imaging
Phosphorous ³² P	Half-life 14.282d β^- (1.71)	Chromic phosphate	Therapeutic: Antineoplastic (radiation source) in treatment of peritoneal or pleural effusions caused by metastatic disease
		Labeled red blood cells	Diagnostic: Blood volume deterrn
		Sodium phosphate	Diagnostic: Study of peripheral vascular disease; localization of ocular, brain and skin tumors; study of breast carcinomas Therapeutic: Polycythemia vera; chronic myelocytic leukemia; chronic lymphocytic leukemia; skeletal metastases; antineoplastic (radiation source)
Potassium ⁴³ K	Half-life 22.3h β^- (0.83, 0.46, 1.22, 1.82) γ (0.618, 0.373, 0.39, 0.59, 0.22)	Potassium chloride	Diagnostic: Myocardial scan; deterrn of total exchangeable potassium
⁴² K	Half-life 12.360h β^- (3.52) γ (1.524)	Potassium carbonate	Diagnostic: Localization of brain tumors; deterrn of intracellular fluid space
		Potassium chloride	Diagnostic: Tumor detection; renal blood flow; deterrn of total exchangeable potassium
Radium ²²⁶ Ra	Half-life 1600y α (4.78, 4.60) γ (0.187)	Radium bromide; α and β particles filtered by platinum	Therapeutic: Antineoplastic (radiation source) in interstitial treatment of malignancies such as cancer of uterine cervix and fundus, oral pharynx, urinary bladder, skin and metastatic cancer of lymph nodes
Radon (Radium Emanation) ²²² Rn (Daughter of ²²⁶ Ra)	Half-life 3.825d α (5.49) γ (0.510)	Gaseous radon; α and β particles filtered by 0.3 mm of gold	Therapeutic: See Radium (²²⁶ Ra)
Ruthenium ¹⁰⁶ Ru	Half-life 1.020y β^- (0.039)	Beta ray applicator	Therapeutic: See Strontium (⁹⁰ Sr)
Daughter (¹⁰⁶ Rh)	Half-life 29.80s β^- (3.53, 3.1, 2.4) γ (0.512, 0.622, 1.128)		
Samarium ¹⁵³ Sm	Half life 1.946d β^- (0.81,0.71, 0.64) γ (0.103, 0.070)	Sm-lexidronam (EDTMP)	Therapeutic: Antineoplastic (radiation source) in treatment of bone cancer
Selenium ⁷⁵ Se	Half-life 119.77d K; γ (0.265, 0.136, 0.121, 0.280, 0.401)	Selenomethionine	Diagnostic: Imaging of pancreas and parathyroid glands
Sodium ²⁴ Na	Half-life 14.659h β^- (1.389, 4.17) γ (1.369, 2.754)	Sodium chloride	Diagnostic: Deterrn of circulation times, sodium space, total exchangeable sodium
	²² Na Half-life 2.602y β^+ (0.545, 1.83) K; γ (1.275)	Sodium chloride	Diagnostic: Deterrn of sodium space and total exchangeable sodium
Strontium ⁸⁵ Sr ^{87m} Sr	Half-life 64.84d K; γ (0.514)	Strontium chloride Strontium nitrate	Diagnostic: Bone imaging
	Half-life 2.795h γ (0.388)		

Radioactive Isotopes Used in Medical Diagnosis and Therapy (Continued)

Name and Symbol	Principal Nuclear Properties	Form	Use
Strontium ⁹⁰ Sr Daughter ⁹⁰ Y	Half-life 28.5y β^- (0.546)	Beta ray applicator	Therapeutic: External irradiation for treatment of benign conditions of eye such as pterygia, traumatic corneal ulceration, corneal scars, vernal conjunctivitis, hemangioma of eyelid, vascularization of cornea and in preparation for a corneal transplant
	Half-life 2.671d β^- (2.288) γ (2.186)		
Sulfur ³⁵ S	Half-life 87.51d β^- (0.167)	Sodium sulfate	Diagnostic: Determn of extracellular fluid volume
Technetium ^{99m} Tc	Half-life 6.006h IT; γ (0.141)	Sodium pertechnetate	Diagnostic: Brain imaging. Cerebral angiography; thyroid imaging; salivary gland imaging; placenta localization; blood pool imaging; gastric mucosa imaging; cardiac function studies; renal blood flow studies. Urinary bladder imaging. Nasolacrimal drainage system imaging
		Sodium pertechnetate labeled red blood cells	Diagnostic: Determn of red blood cell volume, short-term survival studies. <i>In vitro</i> compatibility studies
		Tc-albumin	Diagnostic: Blood pool imaging; cardiovascular studies; placenta localization; determn of blood or plasma volumes
		Tc-albumin (aggregated)	Diagnostic: Pulmonary perfusion imaging
		Tc-albumin (microaggregated)	Diagnostic: Liver imaging
		Tc-apcitide	Diagnostic: Acute venous thrombosis imaging
		Tc-arcitumomab	Diagnostic: Tumor detection for colorectal cancer
		Tc-bicisate	Diagnostic: Brain imaging
		Tc-butedronate (DPD)	Diagnostic: Brain imaging
		Tc-depreotide	Diagnostic: Tumor detection for lung cancer
		Tc-disofenin (DISIDA)	Diagnostic: Hepatobiliary imaging
		Tc-etidronate (EHDP)	Diagnostic: Bone imaging
		Tc-exametazine (HM-PAO)	Diagnostic: Cerebral perfusion imaging
		Tc-fanolesomab	Diagnostic: Imaging and diagnosis of infections
		Tc-gluceptate	Diagnostic: Brain imaging; renal imaging; assess renal and brain perfusion
		Tc-labeled red blood cells	Diagnostic: Determn of red cell volume; short-term red cell survival studies
		Tc-lidofenin (HIDA)	Diagnostic: Hepatobiliary imaging
		Tc-mebrofenin	Diagnostic: Hepatobiliary imaging
		Tc-medronate (MDP)	Diagnostic: Bone imaging
		Tc-mertiatide (MAG3)	Diagnostic: Renal imaging
		Tc-oxidronate (HDP)	Diagnostic: Bone imaging
		Tc-pentetate (DTPA)	Diagnostic: Brain imaging; renal imaging; assess renal and brain perfusion; estimate glomerular filtration rate. Lung ventilation studies
		Tc-polyphosphates	Diagnostic: Bone imaging; myocardial imaging; blood pool imaging; detection of gastrointestinal bleeding
		Tc-pyrophosphate	Diagnostic: Bone imaging; cardiac imaging; blood pool imaging; detection of gastrointestinal bleeding
		Tc-sestamibi (HEXAMIBI)	Diagnostic: Myocardial perfusion imaging
		Tc-succimer	Diagnostic: Renal imaging
		Tc-sulesomab	Diagnostic: Detection of infections and inflammation

Radioactive Isotopes Used in Medical Diagnosis and Therapy (Continued)

Name and Symbol	Principal Nuclear Properties	Form	Use
Technetium ^{99m} Tc (Cont'd)		Tc-sulfur colloid	Diagnostic: Liver, spleen and bone marrow imaging. Esophageal transit studies; gastro-esophageal reflux scintigraphy; deternm of pulmonary aspiration of gastric contents; detection of intrapulmonary and lower gastrointestinal bleeding. Lung ventilation imaging
		Tc-teboroxime	Diagnostic: Myocardial perfusion imaging
		Tc-tetrofosmin	Diagnostic: Myocardial perfusion imaging
Thallium ²⁰¹ Tl	Half-life 3.046d K; γ (0.135, 0.167)	Thalious chloride	Diagnostic: Myocardial perfusion imaging; localization of sites of parathyroid hyperactivity
Xenon ¹³³ Xe	Half-life 5.245d β^- (0.346) γ (0.081)	Gas	Diagnostic: Pulmonary perfusion imaging; cerebral blood flow; lung ventilation studies
		Gas in saline solution	Diagnostic: Pulmonary perfusion imaging; regional blood flow; lung ventilation studies
¹²⁷ Xe	Half-life 36.41d K; γ (0.172, 0.203)	Gas	Diagnostic: Pulmonary perfusion imaging; lung ventilation studies
Ytterbium ¹⁶⁹ Yb	Half-life 32.022d K; γ (0.063, 0.100, 0.313, 0.177, 0.198, 0.308)	Yb-pentetate (DTPA)	Diagnostic: Cisternography; brain scan
Yttrium ⁹⁰ Y	Half life 2.671d β^- (2.288) γ (2.186)	Y-edotreotide	Therapeutic: Antineoplastic (radiation source) in treatment of neuroendocrine tumors
		Y-epratuzumab	Therapeutic: Antineoplastic (radiation source) in treatment of non-Hodgkin's lymphoma
		Y-ibritumomab tiuxetan	Therapeutic: Antineoplastic (radiation source) in treatment of non-Hodgkin's lymphoma

References

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Notes

1. The following abbreviations for time units are used: y = years, d = days, h = hours, min = minutes, s = seconds.
2. The column for Principal Nuclear Properties lists the principal modes of disintegration and energies of the radiation in million electronvolts (MeV) for the individual isotopes. Symbols used to represent the modes of decay are: α = alpha particle emission, β^- = beta particle, β^+ = positron, γ = gamma ray, K = electron capture.