References:

Actinium

Isotopes in medicine

1. http://www.studybusiness.com/HTML/Bio/10021/10021-04-2003-BIO-04-E.pdf
2. Ma, D.; McDevitt, M. R.; Finn, R. D.; Scheinberg, D. A., Breakthrough of 225Ac and its radionuclide daughters from an 225Ac/213Bi generator: development of new methods, quantitative characterization, and implications for clinical use. *Applied Radiation and Isotopes* **2001,** *55* (5), 667-678.
3. http://www.sunysccc.edu/academic/mst/ptable/ac.html

Figure 1:
http://www.sc.doe.gov/technology_transfer/success_stories/cancer_treatment_technology.htm

Isotopes in hydrology

1. Geibert, W.; Rutgers van der Loeff, M. M.; Hanfland, C.; Dauelsberg, H. J., Actinium-227 as a deep-sea tracer: sources, distribution and applications. *Earth and Planetary Science Letters* **2002,** *198* (1-2), 147-165.
2. McKenzie, D., Constraints on melt generation and transport from U-series activity ratios. *Chemical Geology* **2000,** *162* (2), 81-94.
3. Moore, W. S.; Ussler Iii, W.; Paull, C. K., Short-lived radium isotopes in the Hawaiian margin: Evidence for large fluid fluxes through the Puna Ridge. *Marine Chemistry* **2008,** *109* (3-4), 421-430.
4. http://www.whoi.edu/page.do?pid=17138

Figure 2:
http://crystoriasplace.com/Dolphin/Underwater_Ocean_Floor_Light_by_Della_Stock.jpg

Aluminium

Isotopes in geology

1. http://www.world-nuclear.org/info/inf56.html
2. http://www.ansto.gov.au/__data/assets/pdf_file/0018/3564/Radioisotopes.pdf
3. http://www.ausetute.com.au/nuclesum.html

Isotopes in hydrology

1. http://www.world-nuclear.org/info/inf56.html
2. http://www.ansto.gov.au/__data/assets/pdf_file/0018/3564/Radioisotopes.pdf
3. http://www.ausetute.com.au/nuclesum.html

Figure 1: http://www.erosionpollution.com/soil-erosion.html

Isotopes in planetary sciences

1. http://www.world-nuclear.org/info/inf56.html
2. http://www.ansto.gov.au/__data/assets/pdf_file/0018/3564/Radioisotopes.pdf
3. http://www.ausetute.com.au/nuclesum.html

Isotopes in tracer studies

1. http://www.world-nuclear.org/info/inf56.html
2. http://www.ansto.gov.au/__data/assets/pdf_file/0018/3564/Radioisotopes.pdf
3. http://www.ausetute.com.au/nuclesum.html

Americium

Isotopes in medicine

1. http://www.newworldencyclopedia.org/entry/Americium
2. http://www.britannica.com/EBchecked/topic/603220/transuranium-element/81202/Practical-applications-of-transuranium-isotopes#ref=ref701046
3. http://www.epa.gov/rpdweb00/radionuclides/americium.html
4. http://www.ead.anl.gov/pub/doc/Americium.pdf

Isotopes in the home

1. http://www.ead.anl.gov/pub/doc/Americium.pdf
2. http://www.britannica.com/EBchecked/topic/603220/transuranium-element/81202/Practical-applications-of-transuranium-isotopes#ref=ref701046
3. http://wwwreno.nrc-cnrc.gc.ca/eng/education/elements/el/am.html
4. http://tap.iop.org/atomic/radioactivity/page_40374.html

Figure 1a: http://tap.iop.org/atomic/radioactivity/page_40374.html

Figure 1b: http://www.sciencelearn.org.nz/Contexts/Just-Elemental/Sci-Media/Images/Smoke-detector-operation

Isotopes in industry

1. http://www.britannica.com/EBchecked/topic/603220/transuranium-element/81202/Practical-applications-of-transuranium-isotopes#ref=ref701046
2. http://www.ead.anl.gov/pub/doc/Americium.pdf
3. http://www.britannica.com/EBchecked/topic/20405/americium#ref=ref61683
4. http://www.chemistryexplained.com/elements/A-C/Americium.html
5. http://www.aboutnuclear.org/view.cgi?fC=Industry,Gamma_-_Radiography

Figure 2: http://www.ronanmeasure.com/tn_radiat.html

Antimony

Isotopes in medicine

1. M.S. Uddin, A. Hermanne, S. Sudar, M.N. Aslam, B. Scholten, H.H. Coenen, S.M. Qaim (2010). "Excitation functions of [alpha]-particle induced reactions on enriched 123Sb and natSb for production of 124I", *Applied Radiation and Isotopes*, In Press, Corrected Proof, Available online 17 December 2010, ISSN 0969-8043, DOI: 10.1016/j.apradiso.2010.12.007.
2. Hassan KF, Qaim SM, Saleh ZA, Coenen HH (2005). "Alpha-particle induced reactions on natSb and 121Sb with particular reference to the production of the medically interesting radionuclide 124I", *Applied Radiation and Isotopes*, 4(1):101-9.
3. Uddin MS, Hermanne A, Sudár S, Aslam MN, Scholten B, Coenen HH, Qaim SM (2010). "Excitation functions of α-particle induced reactions on enriched (123)Sb and (nat)Sb for production of (124)I". *Applied Radiation and Isotopes*, 2010 Dec 17. [Epub ahead of print]
4. K.F. Hassan, S.M. Qaim, Z.A. Saleh, H.H. Coenen (2006), "Alpha-particle induced reactions on natsb and 121sb with particular reference to the production of the medically interesting radionuclide 124I", *Applied Radiation and Isotopes*, 64(1):101-109, ISSN 0969-8043, DOI: 10.1016/j.apradiso.2005.07.007.

Figure 1: http://www.lymphomation.org/treatment-rit.htm

Isotopes as environmental tracers

1. B. Chauvenet, M.-M. Be, M.-N. Amiot, C. Bobin, M.-C. Lepy, T. Branger, I. Laniece, A. Luca, M. Sahagia, A.C. Watjen, K. Kossert, O. Ott, O. Nahle, P. Dryak, J. Sochorova, P. Kovar, P. Auerbach, T. Altzitzoglou, S. Pomme, G. Sibbens, R. Van Ammel, J. Paepen, A. Iwahara, J.U. Delgado, R. Poledna, C.J. da Silva, L. Johansson, A. Stroak, C. Bailat, Y. Nedjadi, P. Spring (2010). "International exercise on 124Sb activity measurements, Applied Radiation and Isotopes", 68(7-8): 1207-1210, Proceedings of the 17th International Conference on Radionuclide Metrology and its Applications (ICRM 2009), ISSN 0969-8043, DOI: 10.1016/j.apradiso.2010.01.037.

Isotopes in industry

1. Rafe Gibbs, "At a Once desolate spot in Idaho the AEC's material-testing reactor is doing vital research for industry" Popular Mechanics, November 1955. Pages 117-121, 234, 236, and 238.

Argon

Isotopes in geochronology

1. Lee, J. K. W., Using argon as a temporal tracer of large-scale geologic processes. *Chemical Geology* **2009,** *266* (1-2), 104-112.
2. http://wwwrcamnl.wr.usgs.gov/isoig/period/ar_iig.html
3. http://anthro.palomar.edu/time/time_5.htm

4. http://geomaps.wr.usgs.gov/common/geochronology.html
5. http://geoinfo.nmt.edu/labs/argon/methods/home.html
Figure 1: http://www.ldeo.columbia.edu/environmental-tracer-group/ar-mass-spec

Isotopes as environmental tracer

1. Christensen, B. P.; Holm, P. M.; Jambon, A.; Wilson, J. R., Helium, argon and lead isotopic composition of volcanics from Santo Antão and Fogo, Cape Verde Islands. *Chemical Geology* **2001,** *178* (1-4), 127-142.
2. Hilton, D. R.; Hammerschmidt, K.; Loock, G.; Friedrichsen, H., Helium and argon isotope systematics of the central Lau Basin and Valu Fa Ridge: Evidence of crust/mantle interactions in a back-arc basin. *Geochimica et Cosmochimica Acta* **1993,** *57* (12), 2819-2841.
3. Lee, J. K. W., Using argon as a temporal tracer of large-scale geologic processes. *Chemical Geology* **2009,** *266* (1-2), 104-112.
4. Sumino, H.; Ikehata, K.; Shimizu, A.; Nagao, K.; Nakada, S., Magmatic processes of Unzen volcano revealed by excess argon distribution in zero-age plagioclase phenocrysts. *Journal of Volcanology and Geothermal Research* **2008,** *175* (1-2), 189-207.
5. http://icebubbles.ucsd.edu/Publications/Kobashi_GCA_methods%201.pdf
Figure 2: http://www.phireflye.com/poems/magma.html

Isotopes in hydrology

1. Loosli, H. H.; Lehmann, B. E.; Balderer, W., Argon-39, argon-37 and krypton-85 isotopes in Stripa groundwaters. *Geochimica et Cosmochimica Acta* **1989,** *53* (8), 1825-1829.
2. Phillips, F. M.; Castro, M. C.; Heinrich, D. H.; Karl, K. T., Groundwater Dating and Residence-time Measurements. *Treatise on Geochemistry*, Pergamon: Oxford, 2003; pp 451-497.
3. Torgersen, T.; Kennedy, B. M.; Hiyagon, H.; Chiou, K. Y.; Reynolds, J. H.; Clarke, W. B., Argon accumulation and the crustal degassing flux of40Ar in the Great Artesian Basin, Australia. *Earth and Planetary Science Letters* **1989,** *92* (1), 43-56.
4. http://www.sahra.arizona.edu/programs/isotopes/argon.html
Figure 3: http://www.anra.gov.au/topics/water/overview/qld/gmu-great-artesian-basin-eastern-recharge-a-queensland.html

Isotopes in medicine

1. Nagatsu, K.; Kubodera, A.; Suzuki, K., A novel way of producing an aqueous solution of 38K+ via the 40Ar(p, 3n)-Process. *Applied Radiation and Isotopes* **1998,** *49* (12), 1505-1510.
2. http://www.tracesciences.com/ar.htm
Figure 4: http://www.piotrnowicki.com/gallery/v/erytrocyty.png.html

Isotopes in industry

1. Mercer, J. R.; Duke, M. J. M.; McQuarrie, S. A., Practical reactor production of 41Ar from argon clathrate. *Applied Radiation and Isotopes* **2000,** *52* (6), 1413-1417.
2. http://www.tracesciences.com/ar.htm

Figure 5: http://store.rilandusa.com/index.php?main_page=product_info&products_id=213

Arsenic

Isotopes in medicine

1. Jennewein, M.; Hermanne, A.; Mason, R. P.; Thorpe, P. E.; Rösch, F., A new method for the labelling of proteins with radioactive arsenic isotopes. *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment* **2006,** *569* (2), 512-517.
2. http://www.ne.doe.gov/isotopes/neIsotopes2eMedical.html
3. http://www.rsc.org/chemistryworld/News/2008/March/05030801.asp

Figure 1: http://www.rsc.org/chemistryworld/News/2008/March/05030801.asp
Figure 2: http://www.rsc.org/chemistryworld/News/2008/March/05030801.asp

Isotopes in tracer studies

1. http://www.ornl.gov/sci/isotopes/isotopenews01.pdf
2. De Kimpe, Jurgen; Cornelis, Rita; Mees, Louis and Vanholder, Raymond, Basal Metabolism of Intraperitoneally Injected Carrier-Free 74As-Labeled Arsenate in Rabbits. *FUNDAMENTAL AND APPLIED TOXICOLOGY* **1996**, *34*, 240-248. http://toxsci.oxfordjournals.org/cgi/reprint/34/2/240.pdf

Astatine

**Applications of astatine isotopes are still being researched and this section will be updated shortly. **

Barium

Isotopes in planetary science

1. Michael C. Ranen and Stein B. Jacobsen (2006). "Barium Isotopes in Chondritic Meteorites: Implications for Planetary Reservoir Models". *Science 3:314 (5800), 809-812. [DOI:10.1126/science.1132595]*
2. Hiroshi Hidaka, Yohei Ohta, Shigekazu Yoneda (2003). "Nucleosynthetic components of the early solar system inferred from Ba isotopic compositions in carbonaceous chondrites", *Earth and Planetary Science Letters*, 214(3-4),455-466. ISSN 0012-821X, DOI: 10.1016/S0012-821X(03)00393-5.
3. S.B. Jacobsen, M.C. Ranen (2006). "Barium isotopes and incomplete mixing in the solar nebula", Geochimica et Cosmochimica Acta. 70(18:1), A286. ISSN 0016-7037, DOI: 10.1016/j.gca.2006.06.580.
4. http://www.tracesciences.com/ba.htm

Figure 1: The Crab Nebula Image credit: NASA/CXC/Rutgers
http://www.flickr.com/photos/28634332@N05/3290907628/

Isotopes in medicine

1. http://www.tracesciences.com/ba.htm

Isotopes in physics

1. http://www.tracesciences.com/ba.htm

Beryllium

Isotopes in geochronology

1. Jordan, C. E., Dibb, J. E., and Finkel, R. C., 2003, ¹⁰Be/⁷ Be tracer of atmospheric transport and stratosphere-troposphere exchange. Journal of Geophysical Research D: Atmospheres, v. 108(8). http://www.scopus.com/inward/record.url?eid=2-s2.0-1642498140&partnerID=40&md5=9b07cdc364f67b562a2f378effbe4674
2. Kaste, J. M., Norton, S. A., and Hess, C. T., 2002, Environmental chemistry of beryllium-7, Reviews in Mineralogy and Geochemistry 50. http://www.scopus.com/inward/record.url?eid=2-s2.0-1142310000&partnerID=40&md5=1188987d1a0850c5adb9143498e53d4d
3. Graly, Joseph A., Bierman, Paul R., Reusser, Lucas J., and Pavich, Milan J., 2010, Meteoric 10Be in soil profiles - A global meta-analysis. Geochimica et Cosmochimica Acta, v. 74(23), p. 6814-6829. http://www.sciencedirect.com/science/article/B6V66-50XCY5C-2/2/75a4679191f533dbe78df9bfb60398db
4. Bierman, Paul R., Caffee, Marc W., Davis, P. Thompson, Marsella, Kim, Pavich, Milan, Colgan, Patrick, Mickelson, David, and Larsen, Jennifer, 2002, Rates and Timing of Earth Surface Processes From In Situ-Produced Cosmogenic Be-10. Reviews in Mineralogy and Geochemistry, v. 50(1), p. 147-205. http://rimg.geoscienceworld.org
5. Reusser, Luke, Bierman, Paul, Pavich, Milan, Larsen, Jennifer, and Finkel, Robert, 2006, An episode of rapid bedrock channel incision during the last glacial cycle, measured with 10Be. American Journal of Science, v. 306(2), p. 69-102. http://www.ajsonline.org/cgi/content/abstract/306/2/69
6. Whitehead, N. E., Endo, S., Tanaka, K., Takatsuji, T., Hoshi, M., Fukutani, S., Ditchburn, R. G., and Zondervan, A., 2008, A preliminary study on the use of 10Be in forensic radioecology of nuclear explosion sites. Journal of Environmental Radioactivity, v. 99(2), p. 260-270. http://www.sciencedirect.com/science/article/B6VB2-4PSJT59-1/2/da6483864d4d896a512849a0116ed202

Figure 1a: JK Böhlke, USGS.
Figure 1b: Reusser, Luke, Bierman, Paul, Pavich, Milan, Larsen, Jennifer, and Finkel, Robert, 2006, An episode of rapid bedrock channel incision during the last glacial cycle, measured with 10Be. American Journal of Science, v. 306(2), p. 69-102.
http://www.ajsonline.org/cgi/content/abstract/306/2/69

Figure 1b: Bierman, P., Zen, E. A., Pavich, M., and Reusser, L., 2004, The incision history of a passive margin river, the Potomac near Great Falls. US Geological Survey Circular(1264), p. 191-221. http://www.scopus.com/inward/record.url?eid=2-s2.0-7244236520&partnerID=40&md5=59dcbb79f3299ea31ee5ba49e918050c

Bismuth

Isotopes in medicine

Figure 1:
http://www.microvet.arizona.edu/courses/VSC519/Secure/CaseMelanoma/CaseMelanoma.htm

Boron

Isotopes in medicine

1. Present status and perspectives of boron neutron capture therapy (1994) D. Gabel, Radiotherapy and Oncology, Vol. 30, 199-205.
2. http://en.wikipedia.org/wiki/Boron_neutron_capture_therapy, retrieved March 22, 2011.
3. Boron neutron-capture therapy (1990) D. N. Slatkin, Neutron News, 1, 25-28.

Isotopes in nuclear physics

1. http://www.orau.org/PTP/collection/proportional%20counters/bf3info.htm, retrieved March 22, 2011.

Isotopes in the environment and tracer studies

1. Boron isotope application for tracing sources of contamination in groundwater (1994) A. Vengosh, K.G. Heumann, S. Jaraske, R. Kasher, Environ. Sci. Technol., 1968-1974.

Figure 1: The isotopic composition of anthropogenic boron and its potential impact on the environment (1998) A. Vengosh, Biological Trace Element Research, 66, 145-151.

Bromine

Isotopes in medicine

1. http://www.tracesciences.com/br.htm
2. Galiano, Eduardo and Tilbury, Roy, The via Cyclotron Production of Carrier-free 77Br the 79Br(p,3n)77Kr--*77Br Reaction using a Liquid Target and On-line Extraction. *Appl. Radiat. lsot.* **1998**, *49*, 105-11.
3. Karen D. McElvany; John A. Katzenellenbogen; Kenneth E. Shafer; Barry A. Siegel; Stephen G. Senderoff; Michael J. Welch and Los Alamos Medical Radioisotope Group, 16α-[77Br]Bromoestradiol: Dosimetry and Preliminary Clinical Studies. *The Journal of Nuclear Medicine* **1982**, *23*(5), 425-430.

Isotopes in tracer studies

1. D'Alessandro, M.; Bidoglio, G.; Mousty, F.; Sala Benito, J. V.; De Llano A. Y., Laboratory and in situ investigation of the isotopic ratio $^{79}Br/^{81}Br$ as a tracer of water migration in crystalline rocks. *Journal of Hydrology* **1997**, *193*(1-4), 351-362.
2. http://www.iconisotopes.com/code/Catalog.pdf

Figure 1: http://toxics.usgs.gov/highlights/hormones_degrade.html

Isotopes in nuclear research

1. Nollet, Leo M. L.; Rathore, Hamir Singh, Handbook of pesticides: methods of pesticide residues analysis. Boca Raton, Fl: CRC Press, 2010. http://books.google.com/books?id=pSsz45_yAP4C&pg=PT49&lpg=PT49&dq=pesticides+%2Bisotope+%2Bbromine&source=bl&ots=8Fa_UIv5Rp&sig=WwPyjAjIKL4BJ5upCPXlwvYBa7w&hl=en&ei=_CEVS-fQLMnTlAeGuenSBQ&sa=X&oi=book_result&ct=result&resnum=4&ved=0CBcQ6AEwAzgK#v=onepage&q=pesticides%20%2Bisotope%20%2Bbromine&f=false
2. http://archaeometry.missouri.edu/naa_overview.html
3. http://www.elementalanalysis.com/services/neutron-activation-analysis-naa

Figure 2: http://archaeometry.missouri.edu/naa_overview.html

Cadmium

Isotopes in environmental science

1. Croteau, M.-N., & S.N. Luoma. "Predicting dietborne metal toxicity from metal influxes". *Environmental Science and Technology* **2009**, 43, 4915-4921.
2. Croteau, M.-N.; Luoma, S. N.; Pellet, B. "Determining metal assimilation efficiency in aquatic invertebrates using enriched stable metal isotope tracers". *Aquatic Toxicology* **2007**, 83, 116–125.
3. Francois Lacan, Roger Francois, Yongcheng Ji, Robert M. Sherrell (2006). "Cadmium isotopic composition in the ocean". Geochimica et Cosmochimica Acta, 70(20), 5104-5118. ISSN 0016-7037, DOI: 10.1016/j.gca.2006.07.036. (http://www.sciencedirect.com/science/article/B6V66-4M0J4RT-3/2/9171a975b544e10117c46be534ced896)

Figure 1: Ecophysiology, Biochemistry and Toxicology http://www.ecotox.be/node/91

Caesium (Cesium)

Isotopes as environmental tracers

1. Olsen, C. R., I. L. Larson, P. D. Lowry, C. R. Moriones, C. J. Ford, K. C. Dearstone, R. R. Turner, B. L. Kimmel, and C. C. Brandt (1992). "Transport and accumulation of

cesium-137 and mercury in the clinch River and Watts Bar Reservoir system". Oak Ridge National Laboratory Technical Publication ORNL/ER-7, Oak Ridge National Laboratory, Oak Ridge, TN 37831, USA.
2. Marc S. Humphries, Andrew Kindness, William N. Ellery, Jeffrey C. Hughes, Claudia R. Benitez-Nelson (2010). "^{137}Cs and ^{210}Pb derived sediment accumulation rates and their role in the long-term development of the Mkuze River floodplain, South Africa". Geomorphology 119 (2010) 88–96.
3. W. G. Winn (1995), "Environmental measurements at the Savannah River Site with underwater gamma detectors". Journal of Radioanalytical and Nuclear Chemistry, 195(2), 345-350. DOI: 10.1007/BF02038433
4. A. V. Chesnokov, A. P. Govorun, V. N. Fedin, O. P. Ivanov, V. I. Liksonov, V. N. Potapov, S. B. Shcherbak, S. V. Smirnov, L. I. Urutskoev, (1999). "Method and device to measure 137Cs soil contamination in-situ". *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment*, 420(1-2), 336-344. ISSN 0168-9002, DOI: 10.1016/S0168-9002(98)00761-X.
5. GRAY, S. N., DIGHTON, J., OLSSON, S. and JENNINGS, D. H. (1995). "Real-time measurement of uptake and translocation of ^{137}Cs within mycelium of *Schizophyllum commune* Fr. by autoradiography followed by quantitative image analysis". *New Phytologist*, 129: 449–465. doi: 10.1111/j.1469-8137.1995.tb04316.x

Figure 1: http://research.esd.ornl.gov/CRERP/WATTSBAR/INDEX.HTM

Isotopes in the food industry

1. HAYER, D. W., (1990). "FOOD IRRADIATION: BENEFITS AND CONCERNS". *Journal of Food Quality*, 13: 147–169. doi: 10.1111/j.1745-4557.1990.tb00014.x

Calcium

Isotopes in medicine

1. http://www.encyclopedia.com/doc/1G2-3427000027.html
2. http://www.tracesciences.com/ca.htm
3. Institute of Medicine. Isotopes for medicine and the life sciences. [Adelstein, S. J., Manning, Frederick J.] Washington, DC: National Academy Press, 1995. [20-25.] http://books.google.com/books?id=7GIZt27ghV4C&pg=PA21&lpg=PA21&dq=calcium-44+and+use&source=bl&ots=tJx_j47QCY&sig=4z5tm8q_nIQQtIZb-eQF0--hHCk&hl=en&ei=dzn8StPUGtP5nAe3_KmaBQ&sa=X&oi=book_result&ct=result&resnum=3&ved=0CA4Q6AEwAg#v=onepage&q=calcium-44%20and%20use&f=false

Figure 1: http://www.nlm.nih.gov/medlineplus/ency/imagepages/9151.htm

Isotopes in tracer studies

1. http://www.encyclopedia.com/doc/1G2-3427000027.html

2. Institute of Medicine. Isotopes for medicine and the life sciences. [Adelstein, S. J., Manning, Frederick J.] Washington, DC: National Academy Press, 1995. [20-25.] http://books.google.com/books?id=7GIZt27ghV4C&pg=PA21&lpg=PA21&dq=calcium-44+and+use&source=bl&ots=tJx_j47QCY&sig=4z5tm8q_nIQQtIZb-eQF0--hHCk&hl=en&ei=dzn8StPUGtP5nAe3_KmaBQ&sa=X&oi=book_result&ct=result&resnum=3&ved=0CA4Q6AEwAg#v=onepage&q=calcium-44%20and%20use&f=false
3. Thomas Walczyk. The potential of inorganic mass spectrometry in mineral and trace element nutrition research. *Fresenius J Anal Chem* **2001**, *370* :444–453.

Isotopes in stellar studies

1. http://wwwrcamnl.wr.usgs.gov/isoig/period/ca_iig.html
2. http://www.encyclopedia.com/doc/1G2-3427000027.html

Californium

Isotopes in medical physics

1. Californium-252: A remarkable versatile radioisotope. (1995) I.W. Osbourne-Lee, C.W. Alexander, Manuscript prepared for Oak Ridge National Laboratory, ORNL/TM-12706.
2. http://www.evs.anl.gov/pub/doc/Californium.pdf

Figure 1: http://www.klzhealthcare.com/klz-Neutron_afterloader.html

Isotopes in nuclear physics

1. http://en.wikipedia.org/wiki/Californium, retrieved March 21, 2011.
2. http://www.evs.anl.gov/pub/doc/Californium.pdf, retrieved March 21, 2011.

Isotopes in industry

1. http://www.evs.anl.gov/pub/doc/Californium.pdf

Carbon

Isotopes in the environment

Figure 1: http://www.ndt-ed.org/EducationResources/CommunityCollege/Radiography/Physics/carbondating.htm

Isotopes in medicine

1. http://www.ead.anl.gov/pub/doc/carbon14.pdf

Cerium

**Applications of cerium isotopes are still being researched and this section will be updated shortly. **

Chlorine

Isotopes in geochronology

1. Phillips, F.M., 2000, Chlorine-36. in Cook, P. G., and Herczeg, A. L., eds., Environmental tracers in subsurface hydrology: Kluwer, Boston, p. 299-348.
2. Phillips, F.M., Mattick, J.L., Duval, T.A., Elmore, D., and Kubik, P.W., 1988, Chlorine 36 and tritium from nuclear weapons fallout as tracers for long-term liquid and vapor movement in desert soils. Water Resources Research, v. 24, p. 1877-1891.

Isotopes in forensics

1. Eggenkamp, H. G. M., Kreulen, R., and Koster Van Groos, A. F., 1995, Chlorine stable isotope fractionation in evaporites. Geochimica et Cosmochimica Acta, v. 59(24), p. 5169-5175. http://www.sciencedirect.com/science/article/B6V66-3YYTJVS-12/2/3b3e992a4a0cd627e191dda71c593380
2. Stewart, Michael A., and Spivack, Arthur J., 2004, The stable-chlorine isotope compositions of natural and anthropogenic materials. Reviews in Mineralogy and Geochemistry, v. 55(1), p. 231-254. http://rimg.geoscienceworld.org
3. Böhlke, J.K, Sturchio, N.C., Gu, B., Horita, J., Brown, G.M., Jackson, W.A., Batista, J.R., and Hatzinger, P.B., 2005, Perchlorate isotope forensics. Analytical Chemistry, v. 77, p. 7838 -7842. http://pubs.acs.org/doi/abs/10.1021/ac051360d

Figure 1: Böhlke, J.K., Hatzinger, P., Sturchio, N.C., Gu, B., Abbene, I.J., and Mroczkowski, S.J., 2009, Atacama perchlorate as an agricultural contaminant in groundwater: Chemical and isotopic evidence from Long Island, New York, USA. Environmental Science and Technology, v. 43, p. 5619–5625. http://pubs.acs.org/doi/abs/10.1021/es9006433

Chromium

Isotopes on medicine

1. Chromium isotopes and the fate of hexavalent chromium in the environment (2002) A.S. Ellis, T.M. Johnson, T.D. Bullen, Science, 295, 2060-2062.

Isotopes in planetary science

1. Extreme 54Cr-rich nano-oxides in the CI chondrite Orgueil – Implication for a late supernova injection into the solar system (2010) L. Qin, L.R. NIttler, C.M.O'D. Alexander, J. Wang, F.J. Stadermann, R.W. Carlson. Geochim. Cosmochim. Acta, 75, 629-644.

Isotopes in environmental studies

1. Chromium isotopes and the fate of hexavalent chromium in the environment (2002) A.S. Ellis, T.M. Johnson, T.D. Bullen, Science, 295, 2060-2062.

Cobalt

Isotopes in medicine

1. http://www.ead.anl.gov/pub/doc/Cobalt.pdf
2. http://www.doh.wa.gov/ehp/rp/factsheets/factsheets-pdf/fs26co60.pdf
3. http://www.epa.gov/rpdweb00/radionuclides/cobalt.html
4. http://www.britannica.com/EBchecked/topic/123274/cobalt-processing/81958/Cobalt-60#ref=ref623150
5. http://www.chemistryexplained.com/elements/A-C/Cobalt.html
6. http://www.helium.com/items/876792-an-overview-of-cobalt-radioisotopes-in-medicine
7. http://www.mondofacto.com/facts/dictionary?cobalt-60
8. http://www.mondofacto.com/facts/dictionary?cobalt-57
9. http://www.rsc.org/chemsoc/visualelements/pages/pdf/cobalt.PDF

Figure 1: http://nyp.org/health/radiology-radiosur.html

Isotopes in food

1. http://www.chemistryexplained.com/elements/A-C/Cobalt.html
2. http://www.britannica.com/EBchecked/topic/123274/cobalt-processing/81958/Cobalt-60#ref=ref623150
3. http://www.mondofacto.com/facts/dictionary?cobalt-57
4. http://www.rsc.org/chemsoc/visualelements/pages/pdf/cobalt.PDF

Figure 2: http://ccr.ucdavis.edu/irr/what2.shtml

Isotopes in industry

1. http://www.epa.gov/rpdweb00/radionuclides/cobalt.html
2. http://www.chemistryexplained.com/elements/A-C/Cobalt.html
3. http://www.world-nuclear.org/info/inf55.html
4. http://www.azom.com/details.asp?ArticleID=596

Figure 3: http://www.altec-ndt.com/products.aspx?CatID=1

Copper

Isotopes in medicine

1. Jadvar, H. & Parker, J. A. (2005). Clinical PET and PET/CT. Springer-Verlag London Limited. Page 70. Retrieved from website: http://books.google.com/books?id=FhkLE8MC71IC&pg=PA70&lpg=PA70&dq=Copper62PTSM+AND+FLOW&source=bl&ots=FSam5nVUpl&sig=qyH73wz3IpRewEyB72Eb

MO4ylgQ&hl=en&ei=JFZZTPvtFoGinAeK09D1CQ&sa=X&oi=book_result&ct=result&resnum=4&ved=0CCAQ6AEwAzgU#v=onepage&q&f=false
2. Herrero, P., Markham, J., Weinheimer, C. J., Anderson, C. J., Welch, M. J., Green, M. A., & Bergmann, S. R. (1993). Quantification of regional myocardial perfusion with generator-produced 62Cu-PTSM and positron emission tomography. *Circulation.* 87;173-183. Retrieved from website: http://circ.ahajournals.org/cgi/reprint/87/1/173.pdf
3. Monica, S. & Anderson, C.J. (2009). Molecular imaging of cancer with copper-64 radiopharmaceuticals and positron emission tomography (PET). *Accounts of Chemical Research*. Vol.42, Iss.7; p.832-841. Retrieved from website: http://pubs.acs.org/doi/abs/10.1021/ar800255q

Figure 1: http://pubs.acs.org/doi/abs/10.1021/ar800255q

Isotopes in tracer studies/nutrition

1. Turnlund, J. R. (1983). Use of enriched stable isotopes to determine bioavailability of trace elements in humans. Science of The Total Environment. Volume 28, Issues 1-3, Pages 385-392. Retrieved from website: http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V78-4HHXWYN17&_user=696292&_coverDate=12%2F31%2F1983&_rdoc=1&_fmt=high&_orig=search&_sort=d&_docanchor=&view=c&_searchStrId=1421080044&_rerunOrigin=google&_acct=C000038819&_version=1&_urlVersion=0&_userid=696292&md5=825d1049314f0fb337508d5bfe8ae5b1
2. Harvey, L. J., Dainty, J. R., Hollands, W. J., Bull, V. J., Beattie, J. H., Venelinov, T. I., Hoogewerff, J. A., Davies, I. M., & Fairweather-Tait, S. J. (2005). Use of mathematical modeling to study copper metabolism in humans. American Journal of Clinical Nutrition, Vol. 81, No. 4, pages 807-813. Retrieved from website: http://www.ajcn.org/cgi/content/full/81/4/807

Curium

**Applications of curium isotopes are still being researched and this section will be updated shortly. **

Darmstadtium

1. http://www.angelo.edu/faculty/kboudrea/periodic/trans_transition.htm
2. http://old.iupac.org/news/archives/2003/naming110.html
3. http://www.lbl.gov/abc/wallchart/teachersguide/pdf/Chap08.pdf
4. http://education.jlab.org/itselemental/ele110.html

Figure 1: http://www.gsi.de/portrait/ueberblick_e.html
Figure 2: http://www.countrysprings.ca/Majlo%20Site/Majlo2.html

Dysprosium

Isotopes in physics

1. Youn, Seo Ho; Lu, Mingwu; Ray, Ushnish; Lev, Benjamin L. (2010). "Dysprosium magneto-optical traps", American Physical Scoiety, Physical Review A, 82(4): id. 043425, doi: 10.1103/PhysRevA.82.043425
2. Victoria E. Ceron, Jorge G. Hirsch (1999). "Double electron capture in 156Dy, 162Er and 168Yb". Physics Letters B, 471(1); 1-5, ISSN 0370-2693, DOI: 10.1016/S0370-2693(99)01317-9.
3. Cohen, R.L. (1965). "Mössbauer Effect in Dy160", Physical Review, 137(6A): 1809-1813. DOI: 10.1103/PhysRev.137.A1809

Figure 1: http://physics.illinois.edu/news/story.asp?id=454 and http://physics.illinois.edu/people/Lev/DSC00662.jpg

Isotopes in medicine

1. D. Ma, A. R. Ketring, G. J. Ehrhardt and W. Jia (1996). Production of radiolanthanides and radiotherapy research at MURR. Journal of Radioanalytical and Nuclear Chemistry. 206(1), 119-126, DOI: 10.1007/BF02040048.
2. S. MIRZADEH, R. E. SCHENTER, A. P. CALLAHAN, F. F. KNAPP, JR. (1992). Production Capabilities in U.S. Nuclear Reactors for Medical Radioisotopes U.S. Department of Energy.
3. G. Ferro-Flores, O. Hernandez-Oviedo, C. Arteaga de Murphy, J. I. Tendilla, F. Monroy-Guzman, M. Pedraza-Lopez, K. Aldama-Alvarado (2004) "[166Dy]Dy/166Ho hydroxide macroaggregates: an in vivo generator system for radiation synovectomy", *Applied Radiation and Isotopes*, 61(6); 1227-1233. ISSN 0969-8043, DOI:10.1016/j.apradiso.2004.04.018.
4. Susanta Lahiri, Kees J. Volkers, Birgit Wierczinski (2004), "Production of 166Ho through 164Dy(n,[gamma])165Dy(n, [gamma])166Dy([beta]-)166Ho and separation of 166Ho", *Applied Radiation and Isotopes*, 61(6); 1157-1161, ISSN 0969-8043, DOI: 10.1016/j.apradiso.2004.03.117.
5. Sledge, C. B., Zuckerman, J. D., Zalutsky, M. R., Atcher, R. W., Shortkroff, S., Lionberger, D. R., Rose, H. A., Hurson, B. J., Lankenner, P. A., Anderson, R. J. and Bloomer, W. A. (1986), Treatment of rheumatoid synovitis of the knee with intraarticular injection of dysprosium 165-ferric hydroxide macroaggregates. Arthritis & Rheumatism, 29: 153–159. doi: 10.1002/art.1780290201

Europium

**Applications of europium isotopes are still being researched and this section will be updated shortly. **

Erbium

Isotopes in medicine

1. F.M. van der Zanta, Z.N. Jahangierb, G.G.M. Gommansa, J.D. Moolenburghc & J.W.G. Jacobsb. (June 2007). Radiation synovectomy of the upper extremity joints: Does leakage from the joint to non-target organs impair its therapeutic effect? *Applied Radiation and Isotopes.* Volume 65, Issue 6, Pages 649-655.
2. Sung-Jae Kim & Kwang-Am Jung. (December 2007). Arthroscopic Synovectomy in Rheumatoid Arthritis of Wrist. *Clinical Medicine & Research.* Volume 5, Number 4 : 244 -250. Retrieved from web address: http://www.clinmedres.org/cgi/content/full/5/4/244
3. M. E. A. McNeil. (2005). *The first year--rheumatoid arthritis: an essential guide for the newly diagnosed.* Marlowe & Company: New York, NY. Pages 4-8. Retrieved from web address: diagnosed.http://books.google.com/books?id=XiLiyDCLlVUC&printsec=frontcover&dq=rheumatoid+arthritis&hl=en&ei=DD4WTIbqN8WclgfSsoDPDA&sa=X&oi=book_result&ct=result&resnum=5&ved=0CEcQ6AEwBA#v=onepage&q&f=false
4. G. Prabhakar, S.S. Sachdev & Dr N. Sivaprasad. (June 2009). Radiation synovectomy (RS), an effective radiotherapy using radiopharmaceuticals for the treatment of inflammatory joint disorders. Pharma Times.Vol 41 - No. 6. Pages 11-14.

Figure 1: http://www.ekoxray.com/images/radiation_leaf.pdf
Figure 2: http://www.ipapharma.org/pt/june2009/Article%20-%20Radiation%20Synovectomy%20(RS).pdf
Figure 3 (graphic and info): http://www.smhrheumatology.com/documents/Radionuclide%20Synovectomy%20Final%20J%20Hochman.pdf

Isotopes in tracer studies

1. Alan Parr, Robert M. Beihn, & Michael Jay. (October 1986). Radiolabeling of an enteric coated tablet by (n,γ) radioactivation of erbium-170 for scintigraphic imaging. International Journal of Pharmaceutics. Volume 32, Issues 2-3, Pages 251-256.
2. M. C. Theodorakis. External scintigraphy in measuring rate of gastric emptying in beagles. (1980). American Physiological Society. Gastrointestinal and Liver Physiology, Vol 239, Issue 1 39-G43. Retrieved from website: http://ajpgi.physiology.org/cgi/content/abstract/239/1/G39

Fermium

Figure 1: http://upload.wikimedia.org/wikipedia/commons/5/58/Ivy_Mike_-_mushroom_cloud.jpg

Fluorine

Isotopes in medicine

1. Krebs, Robert. The history and use of our earth's chemical elements: a reference guide. Westport, CT: Greenwood Press, 2006.
2. http://www.chemistryexplained.com/elements/C-K/Fluorine.html
3. http://www.world-nuclear.org/info/inf55.html

4. http://www.asqlongisland.org/seminars/LM_Amer_Soc_for_QA_talk_11_8_07.pdf

Figure 1: http://pubs.niaaa.nih.gov/publications/arh313/233-237.htm

Francium

1. http://www.sunysccc.edu/academic/mst/ptable/fr.html
2. http://clair.si.umich.edu/clair/corpora/chemical/Francium#Applications
3. http://ucla.academia.edu/EricScerri/Papers/113682/Finding_francium
4. http://education.jlab.org/itselemental/ele087.html

Figure 1: http://www.aip.org/history/newsletter/fall2004/strasbourg-photo.htm

Gadolinium

**Applications of gadolinium isotopes are still being researched and this section will be updated shortly. **

Gallium

Isotopes in medicine

1. Irfan Kayani, Brendon G. Conry, Ashley M. Groves, Thida Win, John Dickson, Martyn Caplin, and Jamshed B. Bomanji. A Comparison of ^{68}Ga-DOTATATE and ^{18}F-FDG PET/CT in Pulmonary Neuroendocrine Tumors. Published online November 12, 2009. *Journal of Nuclear Medicine* **2009**. doi:10.2967/jnumed.109.066639
2. Fani, M., André, J. P. and Maecke, H. R., 2008, ^{68}Ga-PET: a powerful generator-based alternative to cyclotron-based PET radiopharmaceuticals. *Contrast Media & Molecular Imaging*, 3: 53–63. doi: 10.1002/cmmi.232
3. Ehrhardt, G.J., Welch, M.J., 1978, A new germanium-68/gallium-68 generator. *Journal of Nuclear Medicine*. 19: 925.
4. Ehrhardt, G., Wagner, S., Welch, M.J., 1979, Applications of gallium-68 produced by the gallium-68 oxine generator. *Journal of Labelled Compounds and Radiopharmaceuticals*. 16: 111.
5. Cantorias, M.V., Figueroa, S.D., Quinn, T.P., Lever, J.R., Hoffman, T.J., Watkinson, L.D., Carmack, T.L., Cutler, C.S. , 2009, Development of high-specific-activity 68Ga-labeled DOTA-rhenium-cyclized α-MSH peptide analog to target MC1 receptors overexpressed by melanoma tumors. *Nuclear Medicine and Biology*. 36: 505.
6. J.C., Rold, T.L., Sieckman, G.L., Figueroa, S.D., Sublett, S.V., Engelbrecht, H., Cutler, C.S., Jurisson, S.S., Hoffman, T.J., Bottenus, B.N., Garrison, 2008, 68Ga-bombesin antagonist for imaging prostate cancer. *Transactions of the American Nuclear Society*. 98: 802.
7. J Fitzsimmons and R Atcher. A method for the chemical separation of Ge-68 from its daughter Ga-68 to produce Ga-68 in a suitable form for nuclear medicine. Patent Pending. submitted May 2007, DOE reference no.: 109,190.
8. Larson SM, Hoffer PB. Normal patterns of localization. In: Hoffer PB, Bekerman C, Henkin RE, 1978, Gallium-67 Imaging. New York: John Wiley, 23-28.

9. Wirth A, Seymour JF, Hicks RJ, et al. Fluorine-18 fluorodeoxyglucose positron emission tomography gallium-67 scintigraphy, and conventional staging for Hodgkin's disease and non- Hodgkin's lymphoma. Am J Med 2002; 112: 262-8.
10. A Vijayananthan, AV Arumugam, G Kumar, D Harichandra, Mastoiditis secondary to mycobacterium abscessus imaged with gallium-67 scintigraphy. *Biomedical Imaging and Interventional Journal* **2008**, *4*(2):e23. doi: 10.2349/biij.4.2.e23

Figure 1: Irfan Kayani, Brendon G. Conry, Ashley M. Groves, Thida Win, John Dickson, Martyn Caplin, and Jamshed B. Bomanji. A Comparison of ^{68}Ga-DOTATATE and ^{18}F-FDG PET/CT in Pulmonary Neuroendocrine Tumors. Published online November 12, 2009. *Journal of Nuclear Medicine* **2009**. doi:10.2967/jnumed.109.066639

Germanium

Isotopes in physics

1. http://arxiv.org/abs/hep-ex/0404039, retrieved March 21, 2011.
2. http://www.rsc.org/chemistryworld/News/2008/March/05030801.asp, retrieved March 21, 2011.

Isotopes in medicine

1. Vascular imaging of solid tumors in rats with a radioactive arsenic-labeled antibody that binds exposed phosphatidylserine (2008) M. Jennewein, M.A. Lewis, D. Zhao, E. Tsyganov, N. Slavine,J. He, L. Watkins,V.D. Kodibagkar, S. O'Kelly, P. Kulkarni, P.P. Antich, A. Hermanne, F. Rösch, R.P. Mason, P.E. Thorpe, Clin. Cancer Res. 14, 1377-1385.

Gold

Isotopes in medicine

1. Chanda, N.; Kan, P.; Watkinson, L. D.; Shukla, R.; Zambre, A.; Carmack, T. L.; Engelbrecht, H.; Lever, J. R.; Katti, K.; Fent, G. M.; Casteel, S. W.; Smith, C. J.; Miller, W. H.; Jurisson, S.; Boote, E.; Robertson, J. D.; Cutler, C.; Dobrovolskaia, M.; Kannan, R.; Katti, K. V., Radioactive gold nanoparticles in cancer therapy: therapeutic efficacy studies of GA-198AuNP nanoconstruct in prostate tumor-bearing mice. *Nanomedicine: Nanotechnology, Biology and Medicine* **2010,** *6* (2), 201-209.
2. Havard, C. W. H.; McAlister, J., Growing Points: Radioactive Isotopes In Clinical Medicine: II. *The British Medical Journal* **1967,** *2* (5551), 555-559.
3. Khan, M. K.; Minc, L. D.; Nigavekar, S. S.; Kariapper, M. S. T.; Nair, B. M.; Schipper, M.; Cook, A. C.; Lesniak, W. G.; Balogh, L. P., Fabrication of {198Au0} radioactive composite nanodevices and their use for nanobrachytherapy. *Nanomedicine: Nanotechnology, Biology and Medicine* **2008,** *4* (1), 57-69.

4. Spencer, A. M.; Patel, M. P.; Smits, B. J.; Williams, J. D. F., Pancreatic Scanning As A Diagnostic Tool In The District General Hospital. *The British Medical Journal* **1974,** *4* (5937), 153-156.
5. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1609795/pdf/annsurg01311-0068.pdf
6. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1956086/pdf/canmedaj01534-0057.pdf

Figure 1: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1609795/pdf/annsurg01311-0068.pdf
Figure 2: Chanda, N.; Kan, P.; Watkinson, L. D.; Shukla, R.; Zambre, A.; Carmack, T. L.; Engelbrecht, H.; Lever, J. R.; Katti, K.; Fent, G. M.; Casteel, S. W.; Smith, C. J.; Miller, W. H.; Jurisson, S.; Boote, E.; Robertson, J. D.; Cutler, C.; Dobrovolskaia, M.; Kannan, R.; Katti, K. V., Radioactive gold nanoparticles in cancer therapy: therapeutic efficacy studies of GA-198AuNP nanoconstruct in prostate tumor-bearing mice. *Nanomedicine: Nanotechnology, Biology and Medicine* **2010,** *6* (2), 201-209.

Isotopes in tracer studies

1. Jones, K. C.; Peterson, P. J., Gold Uptake by Perennial Ryegrass: The Influence of Humates on the Cycling of Gold in Soils. *Biogeochemistry* **1989,** *7* (1), 3-10.
2. Patrick, G.; Stirling, C., Transport of Particles of Colloidal Gold within and from Rat Lung after Local Deposition by Alveolar Microinjection. *Environmental Health Perspectives* **1992,** *97*, 47-51.

Figure 3: http://www.jstor.org/stable/3431328?seq=3

Hafnium

Isotopes in geochronology

1. Scherer, Erik, Münker, Carsten, and Mezger, Klaus, 2001, Calibration of the lutetium-hafnium clock. Science, v. 293(5530), p. 683-687, http://www.sciencemag.org/content/293/5530/683.abstract.

Figure 1: http://cimss.ssec.wisc.edu/sage/geology/lesson1/concepts.html

Hassium

1. Loveland, W.; Robert, A. M., Nuclear Chemistry. In *Encyclopedia of Physical Science and Technology*, Academic Press: New York, 2001; pp 597-615.
2. http://www.sunysccc.edu/academic/mst/ptable/uno.html
3. http://www.lbl.gov/Science-Articles/Archive/108-chemistry.html
4. http://www.heavyelements.lbl.gov/hresearch.htm
5. http://education.jlab.org/itselemental/ele108.html

Figure 1: http://www.gsi.de/portrait/ueberblick_e.html
Figure 2: http://www.eltiste-kaiser.com/Eltiste%20Kaiser%20Web_files/HessenCoatofArms.htm

Helium

Isotopes in industry and medicine

1. Physics Today, June 2010, p. 22.

Figure 1: http://www.jfims.co.uk/RDP_vpm.php
Figure 2: Cooper, Ron, 2010, Overview of helium-3 demand. AAAS Workshop on Helium-3, Oak Ridge National Laboratory, April 2010. http://cstsp.aaas.org/agenda_meeting.html

Holmium

Isotopes in medicine

Figure 1: http://hanaro.kaeri.re.kr/english/rd_2.htm

Hydrogen

Isotopes in industry

Figure 1: http://www.escapelight.nl/technology.html
Figure 2: http://etd.library.vanderbilt.edu/available/etd-07292009-095958/unrestricted/PMarineMSThesis%5B1%5D.pdf

Indium

Isotopes in medicine

Figure 1: http://tech.snmjournals.org/cgi/content/full/32/2/47

Iodine

Isotopes as environmental tracers

1. D. Elmore, H. E. Gove, R. Ferraro, L. R. Kilius, H. W. Lee, K. H. Chang, R. P. Beukens, A. E. Litherland, C. J. Russo, K. H. Purser, M. T. Murrell & R. C. Finkel (1980). "Determination of ^{129}I using tandem accelerator mass spectrometry". *Nature* 286, 138 – 140. doi:10.1038/286138a0
2. Glen Snyder, Udo Fehn (2004), "Global distribution of 129I in rivers and lakes: implications for iodine cycling in surface reservoirs", *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms,* Volumes 223-224, Proceedings of the Ninth International Conference on Accelerator Mass Spectrometry, Pages 579-586. ISSN 0168-583X, DOI: 10.1016/j.nimb.2004.04.107.

Figure 1: Image: Lanl.gov/science

Isotopes in medicine

1. Venkat R. Narra, Roger W. Howell, Raw S. Harapanhalli, Kandula S. R. Sastry and Dandamudi V. Rao (1992). "Radiotoxicity of Some Iodine-123, Iodine-125, and Iodine-131-Labeled Compounds in Mouse Testes: Implications for Radiopharmaceutical Design". *Journal of Nuclear Medicine*. 33: 2196. http://jnm.snmjournals.org/cgi/reprint/33/12/2196.pdf.

Iridium

Isotopes in medicine

1. http://www.world-nuclear.org/info/inf55.html
2. http://www.world-nuclear.org/info/inf56.html
3. ftp://medical.nema.org/medical/dicom/final/cp623_ft.pdf
4. http://www.ausetute.com.au/nuclesum.html
5. http://www.isotopeworld.com/filestore/MedicalIsotopeProductionandUse.pdf
6. http://www.nap.edu/openbook.php?record_id=4818&page=38
7. http://www.ansto.gov.au/__data/assets/pdf_file/0018/3564/Radioisotopes.pdf

Figure 1:
http://rpop.iaea.org/RPOP/RPoP/Content/InformationFor/HealthProfessionals/2_Radiotherapy/RadSafetyBrachytherapy.htm#Brachy_FAQ02

Isotopes in industrial applications and engineering

1. http://www.world-nuclear.org/info/inf56.html
2. http://www.ansto.gov.au/__data/assets/pdf_file/0018/3564/Radioisotopes.pdf
3. http://www.ausetute.com.au/nuclesum.html

Iron

Isotopes in medicine

1. http://www.world-nuclear.org/info/inf55.html
2. http://www.world-nuclear.org/info/inf56.html
3. ftp://medical.nema.org/medical/dicom/final/cp623_ft.pdf
4. http://www.ausetute.com.au/nuclesum.html
5. http://www.isotopeworld.com/filestore/MedicalIsotopeProductionandUse.pdf
6. http://www.nap.edu/openbook.php?record_id=4818&page=38
7. http://www.ansto.gov.au/__data/assets/pdf_file/0018/3564/Radioisotopes.pdf

Isotopes in geology, hydrology or planetary sciences

1. http://www.world-nuclear.org/info/inf56.html
2. http://www.ansto.gov.au/__data/assets/pdf_file/0018/3564/Radioisotopes.pdf
3. http://www.ausetute.com.au/nuclesum.html

Isotopes in tracer studies

1. http://www.world-nuclear.org/info/inf56.html

2. http://www.ansto.gov.au/__data/assets/pdf_file/0018/3564/Radioisotopes.pdf
3. http://www.ausetute.com.au/nuclesum.html

Isotopes in industrial applications and engineering

1. http://www.world-nuclear.org/info/inf56.html
2. http://www.ansto.gov.au/__data/assets/pdf_file/0018/3564/Radioisotopes.pdf
3. http://www.ausetute.com.au/nuclesum.html

Krypton

Isotopes in medicine

1. http://www.webelements.com/krypton/isotopes.html
2. http://www.chemistryexplained.com/elements/C-K/Krypton.html
3. Adelstein, S. J., Manning, Frederick J. Isotopes for medicine and the life sciences. Washington, D.C.: National Academy Press, 1995.
4. http://www.tracesciences.com/kr.htm
5. http://www.world-nuclear.org/info/inf55.html
6. http://www.sahra.arizona.edu/programs/isotopes/krypton.html

Figure 1: http://www.succeed.ufl.edu/content/abe2062/lect/lect_20/lect_20.html

Isotopes in the environment

1. http://www.sahra.arizona.edu/programs/isotopes/krypton.html
2. http://www.tracesciences.com/kr.htm
3. Martin B. Kalinowski, Hartmut Sartorius, Stefan Uhl, Wolfgang Weiss (2004). Conclusions on plutonium separation from atmospheric krypton-85 measured at various distances from the Karlsruhe reprocessing plant, *Journal of Environmental Radioactivity*,*73*(2), 203-222.

Isotopes in tracer studies

1. Lehman, B.E., Oeschger, H., Loosli., H.H., Hurst, G.S., Allman, S.L., Chen, C.H., Kramer, S.D., Willis, R.D., and Thonnard, N. (1985). "Counting ^{81}Kr atoms for analysis of groundwater". *J. Geophy. Res.*, **90**, 11547-11551.
2. http://www.sahra.arizona.edu/programs/isotopes/krypton.html
3. http://www.deq.state.id.us/inl_oversight/contamination/fact_sheets/krypton.pdf
4. http://wwwrcamnl.wr.usgs.gov/isoig/period/kr_iig.html
5. http://www.tracesciences.com/kr.htm
6. Martin B. Kalinowski, Hartmut Sartorius, Stefan Uhl, Wolfgang Weiss (2004). Conclusions on plutonium separation from atmospheric krypton-85 measured at various distances from the Karlsruhe reprocessing plant, *Journal of Environmental Radioactivity*,*73*(2), 203-222.
7. N. C. Sturchio; X. Du; R. Purtschert; B. E. Lehmann; M. Sultan; L. J. Patterson; Z.-T. Lu; P. Muller; T. Bigler; K. Bailey; T. P. O'Connor; L. Young; R. Lorenzo; R. Becker; Z.

El Alfy; B. El Kaliouby; Y. Dawood and A. M. A. Abdallah, One million year old groundwater in the Sahara revealed by krypton-81 and chlorine-36. *Geophys. Res. Lett.***2004**, *31*, L05503. doi:10.1029/2003GL019234

Isotopes in industry

1. http://wwwrcamnl.wr.usgs.gov/isoig/period/kr_iig.html
2. http://www.chemistryexplained.com/elements/C-K/Krypton.html
3. Krebs, Robert. The history and use of our earth's chemical elements: a reference guide. Westport, CT: Greenwood Press, 2006.
4. http://www.accessexcellence.org/AE/AEC/CC/radio_table.php

Figure 2: http://www.succeed.ufl.edu/content/abe2062/lect/lect_20/lect_20.htm

Lanthanum

**Applications of lanthanum isotopes are still being researched and this section will be updated shortly. **

Lead

Isotopes in the environment

1. Renberg, I.; Brännvall, M.-L.; Bindler, R.; Emteryd, O., Atmospheric Lead Pollution History during Four Millennia (2000 BC to 2000 AD) in Sweden. *Ambio* 2000, *29* (3), 150-156.
2. Reuer, M. K.; Weiss, D. J., Anthropogenic Lead Dynamics in the Terrestrial and Marine Environment. *Philosophical Transactions: Mathematical, Physical and Engineering Sciences* 2002, *360* (1801), 2889-2904.
3. Ewing, Stephanie A.; Christensen, John N.; Brown, Shaun T.; Vancuren, Richard A.; Cliff, Steven S.; Depaolo Donald J., Pb Isotopes as an Indicator of the Asian Contribution to Particulate Air Pollution in Urban California. *Environmental Science & Technology* **2010,** *44* (23), 8911-8916. http://pubs.acs.org/doi/full/10.1021/es101450t
4. http://newscenter.lbl.gov/feature-stories/2010/12/01/lead-isotopes-air-pollution/
5. Cicchella, D.; Vivo, B. De; Lima, A.; Albanese, S.; McGill, R.A.R. and Parrish, R.R., Heavy metal pollution and Pb isotopes in urban soils of Napoli, Italy. *Geochemistry: Exploration, Environment, Analysis* **2008**, *8*, 103–112. http://geea.geoscienceworld.org/cgi/reprint/8/1/103

Figure 1: http://newscenter.lbl.gov/feature-stories/2010/12/01/lead-isotopes-air-pollution/
Figure 2: http://www.artlex.com/ArtLex/r/roman.html

Isotopes in hydrology

1. Bindler, R.; Renberg, I.; Brannvall, M.-L.; Emteryd, O.; El-Daoushy, F., A Whole-Basin Study of Sediment Accumulation Using Stable Lead Isotopes and Flyash Particles in an Acidified Lake, Sweden. *Limnology and Oceanography* **2001,** *46* (1), 178-188.
2. DeLaune, R. D.; Whitcomb, J. H.; Patrick, W. H., Jr.; Pardue, J. H.; Pezeshki, S. R., Accretion and Canal Impacts in a Rapidly Subsiding Wetland. I. 137 Cs and 210 Pb Techniques. *Estuaries* **1989,** *12* (4), 247-259.

Isotopes in forensic science

1. Gulson, B. L.; Gillings, B. R., Lead Exchange in Teeth and Bone: A Pilot Study Using Stable Lead Isotopes. *Environmental Health Perspectives* **1997,** *105* (8), 820-824.
2. Müller, W.; Fricke, H.; Halliday, A. N.; McCulloch, M. T.; Wartho, J.-A., Origin and Migration of the Alpine Iceman. *Science* **2003,** *302* (5646), 862-866.
3. Smith, D. R.; Osterloh, J. D.; Flegal, A. R., Use of Endogenous, Stable Lead Isotopes to Determine Release of Lead from the Skeleton. *Environmental Health Perspectives* **1996,** *104* (1), 60-66.
4. http://news.bbc.co.uk/2/hi/science/nature/3632770.stm

Figure 3: http://www.dailymail.co.uk/sciencetech/article-1159632/Otzi-prehistoric-iceman-goes-online-allowing-users-virtually-tour-body.html

Isotopes in dating/archaeology

1. Brill, R. H., Lead and Oxygen Isotopes in Ancient Objects. *Philosophical Transactions of the Royal Society of London. Series A, Mathematical and Physical Sciences* **1970,** *269* (1193), 143-164.
2. Tatsumoto, M.; Rosholt, J. N., Age of the Moon: An Isotopic Study of Uranium-Thorium-Lead Systematics of Lunar Samples. *Science* **1970,** *167* (3918), 461-463.
3. http://www.sciencedaily.com/releases/2006/04/060404204102.htm
4. http://eg.geoscienceworld.org/cgi/reprint/9/1/1

Isotopes in health/safety

1. Gwiazda, R. H.; Smith, D. R., Lead Isotopes as a Supplementary Tool in the Routine Evaluation of Household Lead Hazards. *Environmental Health Perspectives* **2000,** *108* (11), 1091-1097.

Lithium

Isotopes in medicine

1. http://www.webelements.com/lithium/isotopes.html
2. Adelstein, S. J., Manning, Frederick J. Isotopes for medicine and the life sciences. Washington, D.C.: National Academy Press, 1995.
3. http://www.tracesciences.com/li.htm

4. http://web.mit.edu/nrl/www/bnct/info/description/description.html

Isotopes in the environment

1. Qi, H.P., Coplen, T.B., Wang, Q.Zh. and Yang, Y.H. (1997). "Unnatural Isotopic Composition of Lithium Reagents." *Anal. Chem.*, 69, 19: 4076-4078.
2. Bullen, T.D. and Kharaka, Y.K. (1992). "Isotopic composition of Sr, Nd, and Li in thermal waters from the Norris-Mammoth corridor, Yellowstone National Park and surrounding region." In: *Water-Rock Interaction. Proceedings of the 7th International Symposium on Water-Rock Interaction*, Balkema Publishers, Rotterdam, p. 897.
3. http://wwwrcamnl.wr.usgs.gov/isoig/period/li_iig.html
4. http://www.tracesciences.com/li.htm

Isotopes in industry

1. http://www.tracesciences.com/li.htm
2. http://www.britannica.com/EBchecked/topic/343644/lithium/278858/Nuclear-properties#ref=ref206552
3. http://www.atomicarchive.com/History/hbomb/page_10.shtml
4. http://www.isoflex.com/lithium7.html
5. http://www.fusion-eur.org/fusion_cd/popu.htm
6. http://web.mit.edu/22.012/www/presentations/22.012%20Mark%20Norsworthy.pdf

Figure 1: http://web.mit.edu/22.012/www/presentations/22.012%20Mark%20Norsworthy.pdf

Figure 2: http://web.mit.edu/22.012/www/presentations/22.012%20Mark%20Norsworthy.pdf

Lutetium

Isotopes in medicine

1. Absolute peptide quantification by lutetium labeling and nanoHPLC-ICPMS with isotope dilution analysis (2009) C. Rappel, D. Schaumloöffel, Anal. Chem. 81, 385-393.

Magnesium

Isotopes in planetary sciences

1. http://www.world-nuclear.org/info/inf56.html
2. http://www.ansto.gov.au/__data/assets/pdf_file/0018/3564/Radioisotopes.pdf
3. http://www.ausetute.com.au/nuclesum.html

Figure 1: http://www.bimsociety.org/meteorites4.shtml

Isotopes in tracer studies

1. http://www.world-nuclear.org/info/inf56.html
2. http://www.ansto.gov.au/__data/assets/pdf_file/0018/3564/Radioisotopes.pdf
3. http://www.ausetute.com.au/nuclesum.html

Isotopes in industrial applications and engineering

1. http://www.world-nuclear.org/info/inf56.html
2. http://www.ansto.gov.au/__data/assets/pdf_file/0018/3564/Radioisotopes.pdf
3. http://www.ausetute.com.au/nuclesum.html

Manganese

Isotopes in geology

1. http://www.world-nuclear.org/info/inf56.html
2. http://www.ansto.gov.au/__data/assets/pdf_file/0018/3564/Radioisotopes.pdf
3. http://www.ausetute.com.au/nuclesum.html

Figure 1: http://www.space.dtu.dk/english/research/climate_and_environment.aspx

Isotopes in planetary sciences

1. http://www.world-nuclear.org/info/inf56.html
2. http://www.ansto.gov.au/__data/assets/pdf_file/0018/3564/Radioisotopes.pdf
3. http://www.ausetute.com.au/nuclesum.html

Isotopes in medicine

1. http://www.world-nuclear.org/info/inf55.html
2. http://www.world-nuclear.org/info/inf56.html
3. ftp://medical.nema.org/medical/dicom/final/cp623_ft.pdf
4. http://www.ausetute.com.au/nuclesum.html
5. http://www.isotopeworld.com/filestore/MedicalIsotopeProductionandUse.pdf
6. http://www.nap.edu/openbook.php?record_id=4818&page=38
7. http://www.ansto.gov.au/__data/assets/pdf_file/0018/3564/Radioisotopes.pdf

Isotopes in tracer studies

1. http://www.world-nuclear.org/info/inf56.html
2. http://www.ansto.gov.au/__data/assets/pdf_file/0018/3564/Radioisotopes.pdf
3. http://www.ausetute.com.au/nuclesum.html

Isotopes in environmental studies and climatology

1. http://www.world-nuclear.org/info/inf56.html
2. http://www.ansto.gov.au/__data/assets/pdf_file/0018/3564/Radioisotopes.pdf
3. http://www.ausetute.com.au/nuclesum.html

Meitnerium

1. Loveland, W.; Robert, A. M., Nuclear Chemistry. In *Encyclopedia of Physical Science and Technology*, Academic Press: New York, 2001; pp 597-615.

2. http://www.sunysccc.edu/academic/mst/ptable/une.html
3. http://www.angelo.edu/faculty/kboudrea/periodic/trans_transition.htm
4. http://education.jlab.org/itselemental/ele109.html

Figure 1: http://www.gsi.de/portrait/ueberblick_e.html
Figure 2: http://www.dhm.de/lemo/objekte/pict/meitner/index.html

Mercury

Isotopes in medicine

1. http://www.chemistryexplained.com/elements/L-P/Mercury.html
2. http://www.tracesciences.com/hg.htm

Isotopes in the environment

1. http://www.tracesciences.com/hg.htm

Figure 1: http://www.biology.ualberta.ca/metaalicus/metaalicus.htm

Isotopes in industry

1. http://www.tracesciences.com/hg.htm
2. http://www.chemistryexplained.com/elements/L-P/Mercury.html

Molybdenum

Isotopes in industrial radionuclide production

1. ABRAM, Ulrich and ALBERTO, Roger (2006). "Technetium and rhenium: coordination chemistry and nuclear medical applications". *Journal Braz. Chem. Soc.* [online]. 17(8), 1486-1500 . ISSN 0103-5053. doi: 10.1590/S0103-50532006000800004.
2. Technetium-99m radiopharmaceuticals : manufacture of kits. — Vienna : International Atomic Energy Agency, 2008. p. ; 24 cm. — (Technical reports series, ISSN 0074–1914; no. 466) STI/DOC/010/466 ISBN 978–92–0–100408–6
3. Patent: ^{99m}Technetium generator system. Patent 5774782 Issued on June 30, 1998. Estimated Expiration Date: May 22, 2016.

Figure 1: ABRAM, Ulrich and ALBERTO, Roger (2006). "Technetium and rhenium: coordination chemistry and nuclear medical applications". *Journal Braz. Chem. Soc.* [online]. 17(8), 1486-1500 . ISSN 0103-5053. doi: 10.1590/S0103-50532006000800004.

Neodymium

**Applications of neodymium isotopes are still being researched and this section will be updated shortly. **

Neon

Isotopes in geochronology and earth processes

Figure 1: http://en.wikipedia.org/wiki/File:Yeager-Rock-Erractic-PB110039.JPG

Neptunium

Isotopes in nuclear physics

1. Neptunium Nukes? Little-studied metal goes critical (2002) P. Weiss, Science News, October 26 2002, Vol. 162, retrieved March 21, 2011.
2. Determination of plutonium isotopes and neptunium-237 in environmental samples by inductively coupled plasma mass spectrometry with total sample dissolution (2002) J. Anal. At. Spectrom., 17, 1471-1479.

Nickel

Isotopes in medicine

1. http://www.world-nuclear.org/info/inf55.html
2. http://www.world-nuclear.org/info/inf56.html
3. ftp://medical.nema.org/medical/dicom/final/cp623_ft.pdf
4. http://www.ausetute.com.au/nuclesum.html
5. http://www.isotopeworld.com/filestore/MedicalIsotopeProductionandUse.pdf
6. http://www.nap.edu/openbook.php?record_id=4818&page=38
7. http://www.ansto.gov.au/__data/assets/pdf_file/0018/3564/Radioisotopes.pdf

Isotopes in geology, hydrology or planetary sciences

1. http://www.world-nuclear.org/info/inf56.html
2. http://www.ansto.gov.au/__data/assets/pdf_file/0018/3564/Radioisotopes.pdf
3. http://www.ausetute.com.au/nuclesum.html

Isotopes in tracer studies

1. http://www.world-nuclear.org/info/inf56.html
2. http://www.ansto.gov.au/__data/assets/pdf_file/0018/3564/Radioisotopes.pdf
3. http://www.ausetute.com.au/nuclesum.html

Isotopes in industrial applications and engineering

1. http://www.world-nuclear.org/info/inf56.html
2. http://www.ansto.gov.au/__data/assets/pdf_file/0018/3564/Radioisotopes.pdf
3. http://www.ausetute.com.au/nuclesum.html

Niobium

Isotopes in medicine

1. F. Paquet, P. Houpert, M. Verry, G. Grillon, J. D. Harrison and H. Me´tivier. THE GASTROINTESTINAL ABSORPTION OF 63Ni AND 95Nb IN ADULT AND NEONATAL RATS: EFFECT OF THE CHEMICAL FORM ADMINISTERED. *Radiation Protection Dosimetry* **1998**, *79*, 191–195.
2. Mraz, Frank R. and Eisele, Gerhard R. Gastrointestinal Absorption, Tissue Distribution, and Excretion of 95Nb in Newborn and Weanling Swine and Sheep. *Radiation Research* **1977**, *72* (3), 533-536. (doi: 10.2307/3574616)
3. Ando A, Ando I. Biodistribution of 95Nb and 182Ta in tumor-bearing animals and mechanisms for accumulation in tumor and liver. *J Radiat Res* (Tokyo) **1990**, *31*(1):97-109.
4. Ando A, Ando I. Tumor uptake and biodistribution of various radiolabels. *Acta Radiol Suppl*. **1990**, *374*, 65-74.

Nitrogen

Isotopes in earth system processes and forensics

Figure 1a: Koch, P.L., Fogel, M. L., and Tuross, N., 1994, Tracing the diets of fossil animals using stable isotopes. in Lajtha, K., and Michener, R. H., eds., Stable Isotopes in Ecology and Environmental Science: Blackwell, Boston, p. 63-92.
Figure 1b: Montoya, J.P., 1994, Nitrogen isotope fractionation in the modern ocean: implications for the sedimentary record. in Zahn, R. a. o., ed., Carbon Cycling in the Glacial Ocean: Constraints on the Ocean's Role in Global Change: 117. NATO ASI Series, Springer-Verlag, Berlin, p. 259-279.

Isotopes as tracers

Figure 2: Böhlke, J.K., USGS.
Figure 3: Böhlke, J.K., USGS.

Osmium

Isotopes in geochronology and earth processes

Figure 1: http://en.wikipedia.org/wiki/File:Impact_event.jpg
Figure 2: Paquay, François S., Ravizza, Gregory E., Dalai, Tarun K., and Peucker-Ehrenbrink, Bernhard, 2008, Determining Chondritic Impactor Size from the Marine Osmium Isotope Record. Science, v. 320(5873), p. 214-218.
http://www.sciencemag.org/content/320/5873/214.abstract

Oxygen

Isotopes in the environment

Figure 1: http://water.usgs.gov/nrp/devilshole.html

Palladium

Isotopes in geochronology

1. J. H. Chen and G. J. Wasserburg (1996), Live ^{107}Pd in the early solar system and implications on planetary evolution. In *Earth Processes: Reading the Isotopic Code*, Geophysical Monograph 95, (ed. A. Basu and S. Hart), Washington: Amer. Geophys. U., 1-20.
2. Chen, J.H. and Wasserburg, G.J. (1990). "The isotopic composition of Ag in meteorites and the presence of ^{107}Pd in proto-planets." *Geochim. et Cosmochim. Acta*, **54**: 1729-1743.
3. Dicken, A.P. (1995). "Radiogenic Isotope Geology." Cambridge University Press, New York, 452 pp.
4. Kelly, W.R. and Wasserburg, G.J. (1978). "Evidence for the existence of ^{107}Pd in the early solar-system." *Geophys. Res. Lett.*, **5**: 1079-1082.
5. Wasserburg, G.J. (1985). "Short-lived nuclei in the early solar-system." In: D.C. Black and M.S. Matthews (Eds.), *Protostars and Planets.* Univ. Arizona Press, pp. 703-737.
6. Wasserburg, G.J. and Papanastassiou, D.A. (1982). "Some short-lived nuclides in the early solar-system - a connection with the placental ISM." In: C.A. Barnes, D.D. Clayton and D.N. Schramm (Eds.), *Essays in Nuclear Astrophysics.* Cambridge University Press, pp. 77-140.

Figure 1: The Crab Nebula Image credit: NASA/CXC/Rutgers
http://www.flickr.com/photos/28634332@N05/3290907628/

Phosphorus

Isotopes in medicine

1. Anthony Soon-Whatt Goh, Alexander Yaw-Fui Chung, Richard Houa-Gong Lo, Te-Neng Lau, Sidney Wing-Kwong Yu, May Chng, Somanesan Satchithanantham, Susan Li-Er Loong, David Chee-Eng Ng, Beng-Choo Lim, Stephen Connor, Pierce Kah-Hoe Chow, 2007. A novel approach to brachytherapy in hepatocellular carcinoma using a phosphorous^{32} (^{32}P) brachytherapy delivery device—a first-in-man study. *International Journal of Radiation Oncology*Biology*Physics*, *67*(3), 786-792.
2. www.chemistryexplained.com/elements/L-P/Phosphorus
3. http://www.world-nuclear.org/info/inf55.html
4. http://www.mayoclinic.com/health/polycythemia-vera/DS00919/DSECTION=treatments-and-drugs
5. http://www.eoearth.org/article/Radioisotopes_in_medicine
6. http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1516-89132002000500007&tlng=en&lng=en&nrm=iso
7. http://www.ncbi.nlm.nih.gov/pubmed/1589802

Isotopes in tracer studies

1. C. B. Wilson, A. A. Epenetos, 1987. 6 Use of monoclonal antibodies for diagnosis and treatment of liver tumours. *Bailliére's Clinical Gastroenterology*, *1*(1), 115-130.
2. S.N. Levine, M.P. Stainton, D.W. Schindler. A Radiotracer Study of Phosphorus Cycling in Eutrophic Canadian Shield Lake, Lake 227, Northwest Ontario, Can. *J. Fish. Aquat. Sci. 43*: 366-378.
3. E.K.J. Pauwels, F.J. Cleton, 1984. Radiolabelled monoclonal antibodies: A new diagnostic tool in nuclear medicine. *Radiotherapy and Oncology*, *1*(4), 333-338.
4. Liisa Tuominen, Helinä Hartikainen, Timo Kairesalo, Petra Tallberg, 1998. Increased bioavailability of sediment phosphorus due to silicate enrichment. *Water Research*, *32*(7), 2001-2008.
5. Radioactive Tires Test Wear, 1951. *Popular Science:* Mechanic and Handicraft, Page 91.
6. Krebs, Robert. The history and use of our earth's chemical elements: a reference guide. Westport, CT: Greenwood Press, 2006.
7. http://www.chemistryexplained.com/elements/L-P/Phosphorus.html
8. http://www.chem.duke.edu/~jds/cruise_chem/nuclear/agriculture.html

Figure 1: http://www.chem.duke.edu/~jds/cruise_chem/nuclear/agriculture.html

Platinum

Isotopes in medicine

1. http://www.world-nuclear.org/info/inf55.html
2. http://www.world-nuclear.org/info/inf56.html
3. ftp://medical.nema.org/medical/dicom/final/cp623_ft.pdf
4. http://www.ausetute.com.au/nuclesum.html
5. http://www.isotopeworld.com/filestore/MedicalIsotopeProductionandUse.pdf
6. http://www.nap.edu/openbook.php?record_id=4818&page=38
7. http://www.ansto.gov.au/__data/assets/pdf_file/0018/3564/Radioisotopes.pdf

Isotopes in geology and planetary sciences

1. http://www.world-nuclear.org/info/inf56.html
2. http://www.ansto.gov.au/__data/assets/pdf_file/0018/3564/Radioisotopes.pdf
3. http://www.ausetute.com.au/nuclesum.html

Plutonium

Isotopes in nuclear research

1. http://www.ieer.org/fctsheet/pu-props.html
2. http://www.ead.anl.gov/pub/doc/Plutonium.pdf

Figure 1: http://hyperphysics.phy-astr.gsu.edu/hbase/nucene/reactor.html

Isotopes in industry

1. http://www.ead.anl.gov/pub/doc/Plutonium.pdf
2. http://education.jlab.org/itselemental/ele094.html
3. http://www.britannica.com/EBchecked/topic/603220/transuranium-element/81184/Synthesis-of-transuranium-elements#ref=ref622154
4. http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/plutonium.html
5. http://periodic.lanl.gov/elements/94.html

Figure 2: http://lasp.colorado.edu/tour/science_research/planetary/

Polonium

**Applications of polonium isotopes are still being researched and this section will be updated shortly. **

Potassium

Isotopes in geochemistry

Figure 1: http://www.lsce.ipsl.fr/en/Phocea/Vie_des_labos/Ast/ast_sstechnique.php?id_ast=184

Figure 2: http://anthro.palomar.edu/time/time_5.htm

Promethium

Isotopes in industry

1. Yakubova, Galina N. (2010). "Nuclear Batteries with Tritium and Promethium-147 Radioactive Sources". PhD Dissertation Aug. 20, 2010, University of Illinois Champaign-Urbana. < http://hdl.handle.net/2142/16849>
2. J. K. Shultis and R. E. Faw, *Fundamentals of Nuclear Science and Engineering*, Marcel Dekker, Inc., New York, 2002, 506 pages.

Figure 1: http://nextbigfuture.com/2009/12/nano-to-macro-scale-nuclear-technology.html

Protactinium

Isotopes in geochronology

1. Cheng, H., Edwards, R. Lawrence, Murrell, M. T., and Benjamin, T. M. Uranium-thorium-protactinium dating systematics. *Geochimica et Cosmochimica Acta* **1998**, *62*(21-22), 3437-3452. http://www.sciencedirect.com/science/article/B6V66-3W78JHX-5/2/b8c57503143da35541b7b2af26c9c276
2. Edwards, R.L., Gallup, C.D., and Cheng, H. Uranium-series Dating of Marine and Lacustrine Carbonates. *Reviews in Mineralogy and Geochemistry* **2003**, *52*(1), 363-405. http://rimg.geoscienceworld.org

Figure 1: Henderson, Gideon M. and Anderson, Robert F. The U-series toolbox for paleoceanography (in Uranium-series geochemistry). *Reviews in Mineralogy and Geochemistry* **2003**, 52, 493-531.
http://www.whoi.edu/cms/files/wjenkins/2006/11/HendersonAnderson2003_15903.pdf

Radium

Isotopes in medicine

1. http://www.ead.anl.gov/pub/doc/Radium.pdf
2. http://www.chemistryexplained.com/elements/P-T/Radium.html
3. http://nrc-stp.ornl.gov/narmtoolbox/radium%20faq102008.pdf
4. http://www.nrc.gov/reading-rm/doc-collections/nuregs/brochures/br0217/r1/br0217r1.pdf
5. http://books.google.com/books?id=pWDQnxd-r1UC&pg=PA315&lpg=PA315&dq=is+radium+currently+used+in+brachytherapy%3F&source=bl&ots=x0mogWpjHw&sig=q8A_GgUC5NKuw3LsWQee0MS6MWU&hl=en&ei=0fIDS8eONMaAnQfSmJhi&sa=X&oi=book_result&ct=result&resnum=5&ved=0CBwQ6AEwBA#v=onepage&q=is%20radium%20currently%20used%20in%20brachytherapy%3F&f=false
6. http://www.healthsystem.virginia.edu/uvahealth/adult_radiology/brachy.cfm

Figure 1: http://www.nrc.gov/reading-rm/doc-collections/nuregs/brochures/br0217/r1/br0217r1.pdf (top) http://www.goldbamboo.com/topic-t1676-a1-6Brachytherapy.html (bottom)

Isotopes in tracer studies

1. http://wwwrcamnl.wr.usgs.gov/isoig/period/ra_iig.html
2. http://tc.engr.wisc.edu/uer/uer96/author3/index.html
3. http://www.chemistryexplained.com/elements/P-T/Radium.html
4. http://www.epa.gov/rpdweb00/radionuclides/radon.html

Radon

Isotopes in the environment

1. Kraemer, T.F. and Genereux, D.P. (1998). "Applications of Uranium- and Thorium-Series Radionuclides in Catchment Hydrology Studies." In: C. Kendall and J.J. McDonnell (Eds.), *Isotope Tracers in Catchment Hydrology*, Elsevier, Amsterdam, pp. 679-722.
2. http://wwwrcamnl.wr.usgs.gov/isoig/period/rn_iig.html
3. http://tc.engr.wisc.edu/uer/uer96/author3/index.html
4. http://www.consrv.ca.gov/CGS/minerals/hazardous_minerals/radon/Pages/index.aspx
5. http://www.epa.gov/rpdweb00/radionuclides/radon.html

Figure 1: http://soundwaves.usgs.gov/2004/11/fieldwork2.html

Rhenium

Isotopes in geology and planetary sciences

1. http://www.world-nuclear.org/info/inf56.html
2. http://www.ansto.gov.au/__data/assets/pdf_file/0018/3564/Radioisotopes.pdf
3. http://www.ausetute.com.au/nuclesum.html

Isotopes in medicine

1. http://www.world-nuclear.org/info/inf55.html
2. http://www.world-nuclear.org/info/inf56.html
3. ftp://medical.nema.org/medical/dicom/final/cp623_ft.pdf
4. http://www.ausetute.com.au/nuclesum.html
5. http://www.isotopeworld.com/filestore/MedicalIsotopeProductionandUse.pdf
6. http://www.nap.edu/openbook.php?record_id=4818&page=38
7. http://www.ansto.gov.au/__data/assets/pdf_file/0018/3564/Radioisotopes.pdf

Rhodium

Isotopes in medicine

1. Ketring, A. R., G. J. Ehrhardt, M. F. Embree, T. T. Tyler, J. A. Gawenis, S. S. Jurisson, H. P. Engelbrecht, C. J. Smith, and C. S. Smith. "Revista Medicina Nuclear Alasbimn Journal, Year 5, Nº 19." *Alasbimn Journal*. Jan. 2003. Web. 11 Jan. 2011. <http://www.alasbimnjournal.cl/19/ketringtotal.html>.

Figure 1: Ketring, A. R., G. J. Ehrhardt, M. F. Embree, T. T. Tyler, J. A. Gawenis, S. S. Jurisson, H. P. Engelbrecht, C. J. Smith, and C. S. Smith. "Revista Medicina Nuclear Alasbimn Journal, Year 5, Nº 19." *Alasbimn Journal*. Jan. 2003. Web. 11 Jan. 2011. <http://www.alasbimnjournal.cl/19/ketringtotal.html>.

Roentgenium

1. http://old.iupac.org/news/archives/2004/naming111.html
2. http://www-d0.fnal.gov/hardware/cal/lvps_info/engineering/elements.pdf
3. http://education.jlab.org/itselemental/ele111.html

Figure 1: http://www.gsi.de/portrait/ueberblick_e.html
Figure 2: http://www.odec.ca/projects/2004/sitt4b0/public_html/images/roetengen.jpg

Rubidium

Isotopes in geology

1. http://www.world-nuclear.org/info/inf56.html
2. http://www.ansto.gov.au/__data/assets/pdf_file/0018/3564/Radioisotopes.pdf
3. http://www.ausetute.com.au/nuclesum.html

Isotopes in medicine

1. http://www.world-nuclear.org/info/inf55.html
2. http://www.world-nuclear.org/info/inf56.html
3. ftp://medical.nema.org/medical/dicom/final/cp623_ft.pdf
4. http://www.ausetute.com.au/nuclesum.html
5. http://www.isotopeworld.com/filestore/MedicalIsotopeProductionandUse.pdf
6. http://www.nap.edu/openbook.php?record_id=4818&page=38
7. http://www.ansto.gov.au/__data/assets/pdf_file/0018/3564/Radioisotopes.pdf

Isotopes in tracer studies

1. http://www.world-nuclear.org/info/inf56.html
2. http://www.ansto.gov.au/__data/assets/pdf_file/0018/3564/Radioisotopes.pdf
3. http://www.ausetute.com.au/nuclesum.html

Rutherfordium

Figure 1: http://www.lbl.gov/abc/wallchart/chapters/08/0.html
Figure 2: http://periodic.lanl.gov/104.shtml

Ruthenium

Isotopes in physics

1. Double beta decay of 100Mo to excited final states. (2006) M.J. Hornish, L. De Braeckeleer, A.S. Barabash, V.I. Umatov, Phys. Rev. C. 74, 044314.

Samarium

**Applications of samarium isotopes are still being researched and this section will be updated shortly. **

Scandium

Isotopes in medicine

1. J. K. MILLER AND W. F. BYRNE, Comparison of Scandium-46 and Cerium-144 as Nonabsorbed Reference Materials in Studies with Cattle. *The Journal of Nutrition* 1970: *100*: 1287-1292. http://jn.nutrition.org/content/100/11/1287.full.pdf
2. Wendie T. Anderson and Mette Strand, Stability, Targeting, and Biodistribution of Scandium-46- and Gallium-67-labeled Monocolonal Antibody in Erythroleukemic Mice. *Cancer Res* 1985;*45*:2154-2158. http://cancerres.aacrjournals.org/cgi/reprint/45/5/2154.pdf
3. Eyles, J. E., Spiers, I. D., Williamson, E. D., Alpar, H. O. and Williamson, E. D., 2001, Tissue distribution of radioactivity following intranasal administration of radioactive microspheres. *Journal of Pharmacy and Pharmacology*, 53: 601–607. doi: 10.1211/0022357011775929

4. Miller J.K., Byrne W.F., 1970, Comparison of scandium-46 and cerium-144 as nonabsorbed reference materials in studies with cattle. *Journal of Nutrition*, 100 (1970) 1287–1292.

Isotopes in industry

1. http://www.rsc.org/chemsoc/visualelements/pages/pdf/scandium.PDF

Isotopes in tracer studies

1. http://www.iaea.org/Publications/Magazines/Bulletin/Bull301/30105683538.pdf
2. http://www.iaea.org/Publications/Magazines/Bulletin/Bull292/29205062024.pdf
3. K. Krishnamurthy, S.M. Rao, 1973, Comparison of radioactive glasses of scandium and iridium as tracers in sediment-transport studies, *Journal of Hydrology*, 19(3): 189-204. ISSN 0022-1694, DOI: 10.1016/0022-1694(73)90080-2. http://www.sciencedirect.com/science/article/B6V6C-4876CXS-10/2/d2adc5d2accea1364929e1b235b965e1
4. Ishrat Rehana, K. A.Shahid, S. Husain, Din Muhammad, 1999, Characterization and excitation behaviour studies of radionuclide (scandium) in glass matrix, *Applied Radiation and Isotopes*, 51(1): 115-120. ISSN 0969-8043, DOI: 10.1016/S0969-8043(98)00159-6. http://www.sciencedirect.com/science/article/B6TJ0-3WJDNV4-K/2/30863b72f0010349326e1e5420145de5

Figure 1: Title: Floods in Northern Argentine, NASA Earth Observatory Collection. www.nasaimages.org

Seaborgium

Figure 1: LBNL Science Photo Library http://www.sciencephoto.com/images/imagePopUpDetails.html?pop=1&id=670074695&pviewid=&country=67&search=&matchtype=FUZZY

Selenium

Isotopes in industry

Figure 1: http://www.cetmedway.co.uk/parc.php
Figure 2: http://www.ndt.net/article/apcndt2006/papers/12.pdf

Silicon

Isotopes in hydrology

1. http://www.sahra.arizona.edu/programs/isotopes/silicon.html
2. http://www.gns.cri.nz/help/laboratory/silicon-32.html
3. http://serc.carleton.edu/microbelife/topics/proxies/paleoclimate.html

4. C. Schnabel, J Beer, and H B Clausen, A novel method to determine the half life of ^{32}Si. Geophysical research Abstracts, Vol. 11, EGU2009-10691-1, 2009. EGU General Assembly 2009.

Figure 1: http://www.gns.cri.nz/Home/Services/Laboratories-Facilities/Tritium-and-Water-Dating-Laboratory/Research-Programmes/Climate-change-studies-ice-core-research

Isotopes in technology

1. http://www.appi.keio.ac.jp/Itoh_group/research/

Figure 2: http://www.appi.keio.ac.jp/Itoh_group/research/

Isotopes in the environment

1. http://www.sahra.arizona.edu/programs/isotopes/silicon.html

Figure 3:
http://www.awi.de/en/research/research_divisions/biosciences/marine_biogeosciences/research_themes/silicon_cycle/

2. http://www.aslo.org/lo/toc/vol_45/issue_2/0472.pdf

Silver

Isotopes in geochronology

1. J. H. Chen and G. J. Wasserburg (1996), Live ^{107}Pd in the early solar system and implications on planetary evolution. In *Earth Processes: Reading the Isotopic Code,* Geophysical Monograph 95, (ed. A. Basu and S. Hart), Washington: Amer. Geophys. U., 1-20.
2. Chen, J.H. and Wasserburg, G.J. (1990). "The isotopic composition of Ag in meteorites and the presence of ^{107}Pd in proto-planets." *Geochim. et Cosmochim. Acta*, **54**: 1729-1743.
3. Dicken, A.P. (1995). "Radiogenic Isotope Geology." Cambridge University Press, New York, 452 pp.
4. Kelly, W.R. and Wasserburg, G.J. (1978). "Evidence for the existence of ^{107}Pd in the early solar-system." *Geophys. Res. Lett.*, **5**: 1079-1082.
5. Wasserburg, G.J. (1985). "Short-lived nuclei in the early solar-system." In: D.C. Black and M.S. Matthews (Eds.), *Protostars and Planets.* Univ. Arizona Press, pp. 703-737.
6. Wasserburg, G.J. and Papanastassiou, D.A. (1982). "Some short-lived nuclides in the early solar-system - a connection with the placental ISM." In: C.A. Barnes, D.D. Clayton and D.N. Schramm (Eds.), *Essays in Nuclear Astrophysics.* Cambridge University Press, pp. 77-140.

Figure 1: The Crab Nebula Image credit: NASA/CXC/Rutgers
http://www.flickr.com/photos/28634332@N05/3290907628/

Isotopes as environmental tracers

1. Yan Luo, Ewa Dabek-Zlotorzynska, Valbona Celo, Derek C. G. Muir, Lu Yang (2010). "Accurate and Precise Determination of Silver Isotope Fractionation in Environmental Samples by Multicollector-ICPMS", *Analytical Chemistry*, *82* (9), 3922-3928.

Sodium

Isotopes in medicine

1. http://www.world-nuclear.org/info/inf55.html
2. http://www.world-nuclear.org/info/inf56.html
3. ftp://medical.nema.org/medical/dicom/final/cp623_ft.pdf
4. http://www.ausetute.com.au/nuclesum.html
5. http://www.isotopeworld.com/filestore/MedicalIsotopeProductionandUse.pdf
6. http://www.nap.edu/openbook.php?record_id=4818&page=38
7. http://www.ansto.gov.au/__data/assets/pdf_file/0018/3564/Radioisotopes.pdf

Isotopes in tracer studies

1. http://www.world-nuclear.org/info/inf56.html
2. http://www.ansto.gov.au/__data/assets/pdf_file/0018/3564/Radioisotopes.pdf
3. http://www.ausetute.com.au/nuclesum.html

Isotopes in hydrology

1. http://www.world-nuclear.org/info/inf56.html
2. http://www.ansto.gov.au/__data/assets/pdf_file/0018/3564/Radioisotopes.pdf
3. http://www.ausetute.com.au/nuclesum.html

Strontium

Isotopes in geochronology and forensics

Figure 1: McArthur, J.M., Howarth, R.J., and Bailey, T.R., 2001, Strontium Isotope Stratigraphy: LOWESS Version 3: Best fit to the marine Sr-Isotope Curve for 0-509 Ma and accompanying look-up table for deriving numerical age. Journal of Geology, v. 109, p. 155-170.
Figure 1: http://www.oceanleadership.org/files/USSSP/PDFs/Greatest_Hits/Rhythms/Farrell.pdf
Figure 2: McArthur, J.M., Howarth, R.J., and Bailey, T.R., 2001, Strontium Isotope Stratigraphy: LOWESS Version 3: Best fit to the marine Sr-Isotope Curve for 0-509 Ma and accompanying look-up table for deriving numerical age. Journal of Geology, v. 109, p. 155-170.

Isotopes in fractionation and earth science

1. Rüggeberg, Andres, Fietzke, Jan, Liebetrau, Volker, Eisenhauer, Anton, Dullo, Wolf-Christian, and Freiwald, André, 2008, Stable strontium isotopes ([delta]88/86Sr) in cold-water corals -- A new proxy for reconstruction of intermediate ocean water temperatures.

Earth and Planetary Science Letters, v. 269(3-4), p. 570-575, http://www.sciencedirect.com/science/article/B6V61-4S33N8Y-3/2/e89a0888d593e18057a82093a0278edc
2. Knudson, Kelly J., Williams, Hope M., Buikstra, Jane E., Tomczak, Paula D., Gordon, Gwyneth W., and Anbar, Ariel D., Introducing [delta]88/86Sr analysis in archaeology: a demonstration of the utility of strontium isotope fractionation in paleodietary studies. Journal of Archaeological Science, v. In Press, Corrected Proof http://www.sciencedirect.com/science/article/B6WH8-500SK27-2/2/08dcdc19ca217e3c97c4674774f238e0

Sulfur

Isotopes in tracer studies

1. http://snobear.colorado.edu/Daniel/isotopes/sulfur35.html

Figure 1: http://snobear.colorado.edu/Daniel/isotopes/sulfur35.html

2. Hebert, Craig E., Michael Bur, David Sherman, and J. Laird Shutt. 2008. SULFUR ISOTOPES LINK OVERWINTER HABITAT USE AND BREEDING CONDITION IN DOUBLE-CRESTED CORMORANTS. Ecological Applications. 18:561—567. http://www.esajournals.org/doi/abs/10.1890/07-1278
3. http://www-pub.iaea.org/MTCD/publications/PDF/TCS-20_web.pdf

Isotopes in food authentication

1. http://www.animal-science.org/cgi/reprint/87/3/905

Isotopes in hydrology

1. http://www.sahra.arizona.edu/programs/isotopes/sulfur.htm
2. http://ok.water.usgs.gov/projects/norlan/pdf/cozzarelli_et_al_2000_EST.pdf
3. Edraki, M.; Golding, S.D.; Baublys, K.A.; and Lawrence, M.G., Hydrochemistry, mineralogy and sulfur isotope geochemistry of acid mine drainage at the Mt. Morgan mine environment, Queensland, Australia. *Applied Geochemistry* **2005**, *20* ,789–805. doi:10.1016/j.apgeochem.2004.11.004
4. Kim, Yongje; Lee, Kwang-Sik; Koh, Dong-Chan; Lee, Dae-Ha; Lee, Seung-Gu; Park, Won-Bae; Koh, Gi-Won; and Woo, Nam-Chil, Hydrogeochemical and isotopic evidence of groundwater salinization in a coastal aquifer: a case study in Jeju volcanic island, Korea. *Journal of Hydrology* **2003**, *270*, 282–294. doi:10.1016/S0022-1694(02)00307-4

Tantalum

Isotopes in medicine

1. Lacy, Jeffrey; Nanavaty, Tamanna; Dai, Dayang;Nayak, Nisha; Haynes, Neal and Martin, Christopher. Development and validation of a novel technique for murine first-pass radionuclide angiography with a fast multiwire camera and tantalum 178. *Journal of Nuclear Cardiology* **2001**, *8*, 171-181. http://dx.doi.org/10.1067/mnc.2001.112135
2. http://www.proportionaltech.com/new_site/images/stories/pdf/lacy01.pdf
3. http://www.tracesciences.com/ta.htm
4. Wilson, Richard A;Kopiwoda, Susan Y.; Callahan, Ronald J.; Moore, Richard H.; Boucher, Charles A.; Manspeaker, Henry; Castronovo, Frank P.; Strauss, H. William. Biodistribution of tantalum-178 A short-lived radiopharmaceutical for blood pool imaging. *European Journal of Nuclear Medicine and Molecular Imaging* **1987**, 13, 82-85. http://dx.doi.org/10.1007/BF00256021
5. Noriko Shigeta, Richard M. Lambrecht, H. Matsuoka, A. Osa, M. Koizumi, K. Kobayashi, M. Izumo, K. Hashimoto, T. Sekine. Tantalum-183: Cyclotron production of a neutron-rich biomedical tracer. *Applied Radiation and Isotopes* **1996**, *47* (2), 171-174. ISSN 0969-8043, DOI: 10.1016/0969-8043(95)00254-5. http://www.sciencedirect.com/science/article/B6TJ0-3VSKPVM-6/2/c4358c865e6905c2b43d4954364c8d7d
6. http://www.proportionaltech.com/mwgc.htm
7. Craig J. Hartley, George E. Taffet, Anilkumar K. Reddy, Mark L. Entman, and Lloyd H. Michael. Noninvasive Cardiovascular Phenotyping in Mice. ILAR Journal 2002, 43(3), 147-158. http://dels-old.nas.edu/ilar_n/ilarjournal/43_3/v4303hartley.shtml

Figure 1: http://www.proportionaltech.com/mwgc.htm

Technetium

Isotopes in medicine

1. Patent: Technetium-99m generator system. Patent 5774782 Issued on June 30, 1998. Estimated Expiration Date: May 22, 2016.
2. Pérez Díaz, Marlén, et al. Administered Activity Optimization in Skeletal Scanning using MDP labeled 99Tcm. Alasbimn Journal 4 (16): July 2002. Available from: <http://www.alasbimnjournal.cl/revistas/16/sec_b/0,1990,SCID%253D1490,00.html>
3. Amy Ballard, 2008, Biomarkers Key to Drug Development: Imaging and biomarkers drive drug development engineered for personalized medicine. *Imaging Technology News*, June 2008 Issue. Available from: <http://www.itnonline.net/node/28614>.
4. ABRAM, Ulrich and ALBERTO, Roger. Technetium and rhenium: coordination chemistry and nuclear medical applications. *J. Braz. Chem. Soc.* [online]. 2006, vol.17, n.8 [cited 2011-01-05], pp. 1486-1500. Available from: <http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0103-50532006000800004&lng=en&nrm=iso>. ISSN 0103-5053. doi: 10.1590/S0103-50532006000800004.

5. Technetium-99m radiopharmaceuticals: manufacture of kits. — Vienna: International Atomic Energy Agency, 2008. (Technical reports series, ISSN 0074–1914; no. 466) STI/DOC/010/466 ISBN 978–92–0–100408–6

Figure 1: Amy Ballard, 2008, Biomarkers Key to Drug Development: Imaging and biomarkers drive drug development engineered for personalized medicine. *Imaging Technology News*, June 2008 Issue. Available from: <http://www.itnonline.net/node/28614>.

Tellurium

**Applications of tellurium isotopes are still being researched and this section will be updated shortly. **

Terbium

Isotopes in medicine

1. Zaitseva, N. G.; Dmitriev, S. N.; Maslov, O. D.; Molokanova, L. G.; Starodub, G. Ya.; Shishkin, S. V.; Shishkina, T. V.; Beyer, G. J. Terbium-149 for nuclear medicine. The production of ^{149}Tb via heavy ions induced nuclear reactions. *Czechoslovak Journal of Physics Supplement* **2003**, *53*(1), A455-A458.
2. G. J. Beyer, M. Miederer, S. Vranjes-Duric, J. J. Comor, G. Kunzi, O. Hartley, R. Senekowitsch-Schmidtke, D. Soloviev and F. Buchegger, *Eur. J. Nucl. Med. Mol. Imaging* **2004**, *31*, 547–554.

Figure 1: http://www.lymphomation.org/treatment-rit.htm

Thallium

**Applications of thallium isotopes are still being researched and this section will be updated shortly. **

Thorium

Isotopes in geochronology

1. Zircon U-Th-Pb geochronology by isotope dilution mass spectrometry (ID-TIMS) (2003) R.R. Parrish, S.R. Noble, In Zircon (eds. J. Hanchar and P. Hoskin), Reviews in Mineralogy and Geochemistry, Mineralogical Society of America, ISBN 093995065-0, 183-213.

Figure 1: http://www.deq.idaho.gov/inl_oversight/contamination/fact_sheets/decay_series.pdf

Thulium

Isotopes in medicine

Figure 1: http://www.becomehealthynow.com/article/diagradiology/627/

Tin

Isotopes in medicine

1. Anupam Bishayee, Dandamudi V. Rao, Suresh C. Srivastava, Lionel G. Bouchet,Wesley E. Bolch, and RogerW. Howell, Marrow-Sparing Effects of 117mSn(41)Diethylenetriaminepentaacetic Acid for Radionuclide Therapy of Bone Cancer. *THE JOURNAL OF NUCLEAR MEDICINE* **2000**, *41*(12), 2043-2050. http://jnm.snmjournals.org/cgi/reprint/41/12/2043.pdf
2. Srivastava, Suresh C., The Role of Electron-Emitting Radiopharmaceuticals in the Palliative Treatment of Metastatic Bone Pain and for Radiosynovectomy: Applications of Conversion Electron Emitter Tin-117m. *Brazilian Archives of Biology and Technology* **2007**, *50*, 49-62. ISSN 1516-8913 http://www.scielo.br/pdf/babt/v50nspe/a07v50ns.pdf

Figure 1: Srivastava, Suresh C., The Role of Electron-Emitting Radiopharmaceuticals in the Palliative Treatment of Metastatic Bone Pain and for Radiosynovectomy: Applications of Conversion Electron Emitter Tin-117m. *Brazilian Archives of Biology and Technology* **2007**, *50*, 49-62. ISSN 1516-8913 http://www.scielo.br/pdf/babt/v50nspe/a07v50ns.pdf

3. http://www.tracesciences.com/table.html
4. http://www.mtrules.org/gateway/ShowRuleFile.asp?RID=13605
5. B. Ponsard, S.C.Srivastava, L.F.Mausner, F.F.(Russ)Knapp, M.A.Garland, S.Mirzadeh, Production of Sn-117m in the BR2 high-flux reactor. *Applied Radiation and Isotopes* **2009**, *67*, 1158-1161. doi:10.1016/j.apradiso.2009.02.023

Titanium

Isotopes in the environment

Figure 1: http://www.newscientist.com/article/dn16969-titanium-reveals-explosive-origins-of-the-solar-system.html

Tungsten

Isotopes in geochronology

1. 182Hf chronometer for the early solar system (1983) E.B. Norman, D.N. Schramm, Nature, 304, 515-517.
2. New half-life measurement of 182Hf: Improved chronometer for the early solar system (2004) C. Vockenhuber, F. Oberli, M. Bichler, I. Ahmad, G. Quitté, M. Meier, A. N. Halliday, D.-C. Lee, W. Kutschera, P. Steier, R. J. Gehrke, and R.G. Helmer, Phys. Rev. Letters, 93, 172501.

Figure 1: http://records.viu.ca/~earles/early-core-aug02.htm

Ununpentium

1. "Chemistry : Periodic Table : Ununpentium : Key Information." Web. 07 Mar. 2011. <http://jpkc.whut.edu.cn/web18/main/wangluo/webelements/webelements/elements/text/uup/key.html>.

Figure 1: http://www.nrc-cnrc.gc.ca/eng/education/elements/el/uup.html
Photo credit: Ernest Orlando Lawrence Berkley National Laboratory, University of California.

Ununquadium

1. "Chemistry: Periodic Table: Ununquadium: Key Information." Web. 09 Mar. 2011. <http://jpkc.whut.edu.cn/web18/main/wangluo/webelements/webelements/elements/text/uuq/key.html>.

Figure 1: OGANESSIAN, Yuri TS., Vladamir K. UTYONKOV, and Kenton J. Moody. "JINR. Voyage to Superheavy Island." *JINR*. Web. 09 Mar. 2011.
http://www.jinr.ru/section.asp?sd_id=103

Uranium

Isotopes in geochronology

1. Zircon U-Th-Pb geochronology by isotope dilution mass spectrometry (ID-TIMS) (2003) R.R. Parrish, S.R. Noble, In Zircon (eds. J. Hanchar and P. Hoskin), Reviews in Mineralogy and Geochemistry, Mineralogical Society of America, ISBN 093995065-0, 183-213.

Isotopes in the nuclear industry

1. http://en.wikipedia.org/wiki/Nuclear_fission, retrieved March 21, 2011
2. http://www.kayelaby.npl.co.uk/atomic_and_nuclear_physics/4_7/4_7_1.html, retrieved March 21, 2011.
3. http://web.ead.anl.gov/uranium/pdf/DUCRETEIntroductionJune2003.pdf, retrieved March 21, 2011.

Figure 1: http://www.umich.edu/~gs265/society/nuclear.htm
Figure 2: http://web.ead.anl.gov/uranium/uses/buscase/slide14.cfm

Isotopes in environmental studies

1. 234U/238U activity ratios in freshwaters as tracers of hydrological processes: the Strengbach watershed (Vosges, France) (1999) J. Riotte, F. Chabaux, Geochim. Cosmochim. Acta. 63, 1263-1275.

Vanadium

Isotopes in medicine

1. Sonia M. Brichard, Jean-Claude Henquin. The role of vanadium in the management of diabetes. (1995) *Trends in Pharmacological Sciences*, *16*(8): 265-270.
2. Thompson KH. Vanadium and diabetes. (2009) *Biofactors*, *10*(1):43-51.
3. Adelstein, S. J., Manning, Frederick J. Isotopes for medicine and the life sciences. Washington, D.C.: National Academy Press, 1995. http://books.google.com/books?id=7GIZt27ghV4C&pg=PA21&lpg=PA21&dq=calcium-44+and+use&source=bl&ots=tJx_j47QCY&sig=4z5tm8q_nIQQtIZb-eQF0--hHCk&hl=en&ei=dzn8StPUGtP5nAe3_KmaBQ&sa=X&oi=book_result&ct=result&resnum=3&ved=0CA4Q6AEwAg#v=onepage&q=calcium-44%20and%20use&f=false
4. http://www.lpi.usra.edu/meetings/lpsc2009/pdf/1549.pdf
5. Kenneth J. D. MacKenzie, Mark E. Smith. Multinuclear solid-state NMR of inorganic materials. Oxford: Elsevier Science Ltd, 2002. http://books.google.com/books?id=_nDsTC1wQOwC&pg=PA642&lpg=PA642&dq=NMR+and+vanadium&source=bl&ots=xDk1uofjC9&sig=8M3EwR-V-1cGxhReJJ7qJgA_NYs&hl=en&ei=vi0bS6n5BYPSlAej8ZjyCQ&sa=X&oi=book_result&ct=result&resnum=7&ved=0CCgQ6AEwBg#v=onepage&q=NMR%20and%20vanadium&f=false

Figure 1: http://www.integrativeinc.com/Products/Products-by-Health-Concern/Endocrine-and-Metabolic-Support/Glucose-Metabolism/70129-Clinical-Nutrients-for-Diabetics.aspx

Isotopes in materials science

1. Kenneth J. D. MacKenzie, Mark E. Smith. Multinuclear solid-state NMR of inorganic materials. Oxford: Elsevier Science Ltd, 2002. http://books.google.com/books?id=_nDsTC1wQOwC&pg=PA642&lpg=PA642&dq=NMR+and+vanadium&source=bl&ots=xDk1uofjC9&sig=8M3EwR-V-1cGxhReJJ7qJgA_NYs&hl=en&ei=vi0bS6n5BYPSlAej8ZjyCQ&sa=X&oi=book_result&ct=result&resnum=7&ved=0CCgQ6AEwBg#v=onepage&q=NMR%20and%20vanadium&f=false
2. http://www.lpi.usra.edu/meetings/lpsc2009/pdf/1549.pdf
3. Adelstein, S. J., Manning, Frederick J. Isotopes for medicine and the life sciences. Washington, D.C.: National Academy Press, 1995. http://books.google.com/books?id=7GIZt27ghV4C&pg=PA21&lpg=PA21&dq=calcium-44+and+use&source=bl&ots=tJx_j47QCY&sig=4z5tm8q_nIQQtIZb-eQF0--hHCk&hl=en&ei=dzn8StPUGtP5nAe3_KmaBQ&sa=X&oi=book_result&ct=result&resnum=3&ved=0CA4Q6AEwAg#v=onepage&q=calcium-44%20and%20use&f=false

Isotopes in cosmochemistry

1. http://www.lpi.usra.edu/meetings/lpsc2009/pdf/1549.pdf
2. Kenneth J. D. MacKenzie, Mark E. Smith. Multinuclear solid-state NMR of inorganic materials. Oxford: Elsevier Science Ltd, 2002. http://books.google.com/books?id=_nDsTC1wQOwC&pg=PA642&lpg=PA642&dq=NMR+and+vanadium&source=bl&ots=xDk1uofjC9&sig=8M3EwR-V-

1cGxhReJJ7qJgA_NYs&hl=en&ei=vi0bS6n5BYPSlAej8ZjyCQ&sa=X&oi=book_result&ct=result&resnum=7&ved=0CCgQ6AEwBg#v=onepage&q=NMR%20and%20vanadium&f=false

Figure 2: http://www.laughtergenealogy.com/bin/hubble/thumbs-ss.html

Xenon

Isotopes in geochronology

1. Ozima, M., and Podosek, F.A., 2002, Noble Gas Geochemistry, 2nd Edition. Cambridge University Press, 286 p.
2. Porcelli, D., Ballentine, C.J., and Wieler, R., eds., 2002, Noble gases in geochemistry and cosmochemistry. 47. Mineralogical Society of America, Washington DC, 844 p.
3. Reynolds, J.H., 1963, Xenology. Journal of Geophysical Research, v. 68, p. 2939-2956.

Isotopes in forensics

1. Bowyer, T. W., Schlosser, C., Abel, K. H., Auer, M., Hayes, J. C., Heimbigner, T. R., McIntyre, J. I., Panisko, M. E., Reeder, P. L., Satorius, H., Schulze, J., and Weiss, W., 2002, Detection and analysis of xenon isotopes for the comprehensive nuclear-test-ban treaty international monitoring system. Journal of Environmental Radioactivity, v. 59(2), p. 139-151, http://www.sciencedirect.com/science/article/B6VB2-44Y1P4K-2/2/3ed8dd7f1c0dfd81474209d21b1fe119

Figure 1: Bowyer, T. W., Schlosser, C., Abel, K. H., Auer, M., Hayes, J. C., Heimbigner, T. R., McIntyre, J. I., Panisko, M. E., Reeder, P. L., Satorius, H., Schulze, J., and Weiss, W., 2002, Detection and analysis of xenon isotopes for the comprehensive nuclear-test-ban treaty international monitoring system. Journal of Environmental Radioactivity, v. 59(2), p. 139-151, http://www.sciencedirect.com/science/article/B6VB2-44Y1P4K-2/2/3ed8dd7f1c0dfd81474209d21b1fe119

Isotopes in medicine

1. Bastiaan Driehuys and Laurence W. Hedlund. Imaging Techniques for Small Animal Models of Pulmonary Disease: MR Microscopy. *Toxicol Pathol*, **2007;** *35* (1), 49-58**.** doi: 10.1080/01926230601132048.

Figure 2: Bastiaan Driehuys and Laurence W. Hedlund. Imaging Techniques for Small Animal Models of Pulmonary Disease: MR Microscopy. *Toxicol Pathol*, **2007;** *35* (1), 49-58**.** doi: 10.1080/01926230601132048.

Ytterbium

Isotopes in industry

1. http://www.rsc.org/chemistryworld/podcast/Interactive_Periodic_Table_Transcripts/Ytterbium.asp
2. H. Yamabayashi, Development of Production Techniques for Ytterbium-169 sources, *Radioisotopes* 1994: *43* (5), 296.
3. http://www.tracesciences.com/yb.htm
4. Locating and characterizing disused sealed radioactive sources in historical waste. Vienna: International Atomic Energy Agency, 2008, pg. 23. http://www-pub.iaea.org/MTCD/publications/PDF/Pub1351_web.pdf
5. http://webcache.googleusercontent.com/search?q=cache:bezNpK9KUswJ:www.osti.gov/bridge/servlets/purl/379045-pA4hLX/webviewable/+identify+hold-up+of+radioactivity&cd=4&hl=en&ct=clnk&gl=us

Figure 1: http://jolisfukyu.tokai-sc.jaea.go.jp/fukyu/tayu/act96e/frame0307.html

Figure 2: Locating and characterizing disused sealed radioactive sources in historical waste. Vienna: International Atomic Energy Agency, 2008, pg. 23. http://www-pub.iaea.org/MTCD/publications/PDF/Pub1351_web.pdf

Isotopes in medicine

1. http://emedicine.medscape.com/article/861126-diagnosis
2. http://albert-cordova.com/ans/medical-radiso.pdf
3. http://www.world-nuclear.org/info/inf56.html
4. http://www.tracesciences.com/yb.htm
5. Production techniques and quality control of sealed radioactive sources of palladium-103, iodine-125, iridium-192 and ytterbium-169. Vienna: International Atomic Energy Agency, 2006. http://www-pub.iaea.org/MTCD/publications/PDF/te_1512_web.pdf
6. Lazarescu, G.R. and Battista, J.J., Analysis of the radiobiology of ytterbium-169 and iodine-125 permanent brachytherapy implants. *Phys Med Biol.* 1997: *42*(9), 1727-36.

Figure 3: http://emedicine.medscape.com/article/861126-diagnosis

Isotopes in physics

1. Yoon, T.H. and Park, C.Y., Prospects and Experimental Progress of an Ytterbium Optical Lattice Clock. *Laser Physics* 2005: *15* (7), 1087-1090. http://www.maik.ru/full/lasphys/05/7/lasphys7_05p1087full.pdf
2. http://tf.nist.gov/ofm/calcium/ybhome.htm
3. http://www.nist.gov/public_affairs/techbeat/tb2006_0306.htm#pancakes

Figure 4: http://www.nist.gov/public_affairs/techbeat/tb2006_0306.htm#pancakes
Figure 5: http://www.nist.gov/public_affairs/techbeat/tb2006_0306.htm#pancakes

Yttrium

Isotopes in medicine

1. McDevitt, Michael, Debjit Chattopadhyay, Jaspreet S. Jaggi, Ronald D. Finn, Pat B. Zanzonico, Carlos Villa, Diego Rey, Juana Mendenhall, Carl A. Batt, Jon T. Njardarson, and David A. Scheinberg. "PLoS ONE: PET Imaging of Soluble Yttrium-86-Labeled Carbon Nanotubes in Mice." *PLoS ONE : Accelerating the Publication of Peer-reviewed Science*. 19 Sept. 2007. Web. 06 Jan. 2011. <http://www.plosone.org/article/info:doi/10.1371/journal.pone.0000907>.

Figure 1: http://www.plosone.org/article/info:doi/10.1371/journal.pone.0000907

Figure 2: http://www.plosone.org/article/info:doi/10.1371/journal.pone.0000907

2. South, Christopher D., Marty M. Meyer, Gregory Meis, Edward Y. Kim, Fred B. Thomas, Ali A. Rikabi, Hooman Khabiri, and Mark Bloomston. "Full Text | Yttrium-90 Microsphere Induced Gastrointestinal Tract Ulceration." *World Journal of Surgical Oncology*. 2 Sept. 2008. Web. 06 Jan. 2011. <http://www.wjso.com/content/6/1/93>.

Figure 3: http://radioisotopes.pnl.gov/yttrium-90.stm

Zinc

Isotopes in medicine

1. http://www.tracesciences.com/zn.htm
2. O'Brien, Kimberly; Zavaleta, Nelly; Caulfield, Laura; Wen, Jianping and Abrams, Steven. Prenatal Iron Supplements Impair Zinc Absorption in Pregnant Peruvian Women. *Journal of Nutrition* **2000**, *130*, 2251-2255. http://jn.nutrition.org/content/130/9/2251.abstract
3. Payton K.B., Flanagan P.R., Stinson E.A., Chodirker D.P., Chamberlain M.J. and Valberg L.S. Technique for determination of human zinc absorption from measurement of radioactivity in a fecal sample or the body. *Gastroenterology* 1982, *83*(6), 1264-70. http://www.ncbi.nlm.nih.gov/pubmed/6813186
4. Lowe, N.M., Woodhouse, L.R., Matel, J.S. and King, J.C. Comparison of estimates of zinc absorption in humans by using 4 stable isotopic tracer methods and compartmental analysis. *American Journal of Clinical Nutrition* **2000**, *71*(2), 523-529. http://www.ajcn.org/content/71/2/523.full
5. K. Abbas, J. Kozempel, M. Bonardi, F. Groppi, A. Alfarano, U. Holzwarth, F. Simonelli, H. Hofman, W. Horstmann, E. Menapace, L. Leseticky, N. Gibson. Cyclotron production of 64Cu by deuteron irradiation of 64Zn. *Applied Radiation and Isotopes* **2006**, *64*(9), 1001-1005. ISSN 0969-8043 DOI:10.1016/j.apradiso.2005.12.021. http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6TJ0-4JBGHXY-1&_user=696292&_coverDate=09%2F30%2F2006&_rdoc=1&_fmt=high&_orig=search&_origin=search&_sort=d&_docanchor=&view=c&_searchStrId=1637564594&_rerunOrigin=google&_acct=C000038819&_version=1&_urlVersion=0&_userid=696292&md5=5b4f6b478de72d0bfb358959489b4f12&searchtype=a
6. T. Katabuchi, S. Watanabe, N. S. Ishioka, Y. Iida, H. Hanaoka, K. Endo and S. Matsuhashi, Production of ^{67}Cu via the ^{68}Zn(p,2p)^{67}Cu reaction and recovery of ^{68}Zn

target. *Journal of Radioanalytical and Nuclear Chemistry* **2008**, *277*(2), 467-470, DOI: 10.1007/s10967-007-7144-9 http://www.springerlink.com/content/k0q26p0188h4h538/
7. http://www.tracesciences.com/nutritionalstudiesisotopes.html
8. Griffin IJ, Kim SC, Hicks PD, Liang LK, Abrams SA. Zinc metabolism in adolescents with Crohn's disease. *Pediatric Research* **2004**, *56*(2); 235-239. http://journals.lww.com/pedresearch/Fulltext/2004/08000/Zinc_Metabolism_in_Adolescents_with_Crohn_s.12.aspx
9. Institute of Medicine. Isotopes for medicine and the life sciences. [Adelstein, S. J., Manning, Frederick J.] Washington, DC: National Academy Press, 1995. [20-25.] http://www.nap.edu/openbook.php?record_id=4818&page=20

Isotopes in tracer studies

1. Y. Sivry; J. Riotte; J.E. Sonke; S. Audry; J. Schafer; J. Viers, G. Blanc; R. Freydier; B. Dupre. Zn isotopes as tracers of anthropogenic pollution from Zn-ore smelters The Riou Mort-Lot River system. *Chemical Geology* **2008**, *255*, 295-304. DOI: 10.1016/j.chemgeo.2008.06.038. http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V5Y-4SX3P0X-6&_user=696292&_coverDate=10%2F15%2F2008&_rdoc=1&_fmt=high&_orig=search&_origin=search&_sort=d&_docanchor=&view=c&_searchStrId=1637483162&_rerunOrigin=scholar.google&_acct=C000038819&_version=1&_urlVersion=0&_userid=696292&md5=87f8194e0113e9cc77ee30e24fdfb4d5&searchtype=a
2. Cloquet, Christophe; Carignan, Jean and Libourel, Guy. Isotopic Composition of Zn and Pb Atmospheric Depositions in an Urban/Periurban Area of Northeastern France. *Environmental Science & Technology* **2006,** *40*(21), 6594-6600 http://pubs.acs.org/doi/abs/10.1021/es0609654
3. Chen, Jiubin; Gaillardet, Jerome and Louvat, Pascale. Zinc Isotopes in the Seine River Waters, France: A Probe of Anthropogenic Contamination. *Environmental Science & Technology* **2008,** *42* (17), 6494-6501. http://pubs.acs.org/doi/abs/10.1021/es800725z
4. Moritz Bigalke, Stefan Weyer, Jozef Kobza, Wolfgang Wilcke. Stable Cu and Zn isotope ratios as tracers of sources and transport of Cu and Zn in contaminated soil. *Geochimica et Cosmochimica Acta* **2010**, *74*(23), 6801-6813. ISSN 0016-7037. DOI: 10.1016/j.gca.2010.08.044 http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V66-511TNGN-7&_user=696292&_coverDate=12%2F01%2F2010&_rdoc=1&_fmt=high&_orig=search&_origin=search&_sort=d&_docanchor=&view=c&_searchStrId=1637466451&_rerunOrigin=scholar.google&_acct=C000038819&_version=1&_urlVersion=0&_userid=696292&md5=30cd6bda3f75f865bbeb4f040d0592e3&searchtype=a
5. Dybowska, A.D., et al., Synthesis of isotopically modified ZnO nanoparticles and their potential as nanotoxicity tracers, Environmental Pollution (2010), doi:10.1016/j. envpol.2010.08.032 http://wwwrcamnl.wr.usgs.gov/tracel/references/pdf/Dybowska%20et%20al%202010%20Env%20Poll_in%20press.pdf

Isotopes in industry

1. http://www.tracesciences.com/zn.htm
2. http://www.tracesciences.com/depletedzincisotopes.html

Figure 1: http://www.tracesciences.com/depletedzincisotopes.html

Zirconium

Isotopes in nuclear science

Figure 1: http://www.whatisnuclear.com/articles/nucreactor.html