References

Know how to solve every problem that has ever been solved."
- Richard Feynman

Abed, R. M. M., A. Al-Thukair, and D. de Beer. 2006. Bacterial diversity of a cyanobacterial mat degrading petroleum compounds at elevated salinities and temperatures. FEMS Microbiol. Ecol. **57:**290-301.

Abel, L. M., J. Schineller, P. J. Keck, and J. J. Villafranca. 1995. Effect of metal ligand mutations on phosphoryl transfer reactions catalyzed by *Escherichia coli* glutamine synthetase. Biochemistry **34:**16695-16702.

Abreu, I. A., A. Hearn, H. An, H. S. Nick, D. N. Silverman, and D. E. Cabelli. 2008. The kinetic mechanism of Manganese containing superoxide dismutase from *Deinococcus radiodurans*: A specialized enzyme for the elimination of high superoxide concentrations. Biochemistry **47:**2350-2356.

Altschul, S. F., W. Gish, W. Miller, E. W. Myers, and D. J. Lipman. 1990. Basic local alignment search tool. J. Mol. Biol. **215:**403-410.

Anderson, A. W., H. C. Nordan, R. F. Cain, G. Parrish, and D. Duggan. 1956. Studies on a radio-resistant microccous. Isolation, morphology, cultural characteristics, and resistance to gamma radiation. Food Technol. **10:**575–577.

Antony, C. P., D. Kumaresan, L. Ferrando, R. Boden, H. Moussard, A. F. Scavino, Y. S. Shouche, and J. C. Murrell. 2010. Active methylotrophs in the sediments of Lonar lake, a saline and alkaline ecosystem formed by meteor impact. ISME J. **4:**1470-1480.

Antony, R., P. P. Sujith., S. O. Fernandes., P. Verma., V. D. Khedekar., P. A. Loka Bharathi. 2011. Cobalt immobilization by Manganese oxidizing bacteria from the Indian ridge system. Curr. Microbiol. **62:**840–849.

Appukuttan, D., A. S. Rao, and S. K. Apte. 2006. Engineering of *Deinococcus radiodurans* R1 for bioprecipitation of uranium from dilute nuclear waste. Appl. Environ. Microbiol. **72:**7873-7878.

Archibald, F. S., and I. Fridovich. 1981. Manganese and defenses against oxygen toxicity in *lactobacillus plantarum*. J. Bacteriol. **145:**442-451.

Asker, D., T. S. Awad, L. McLandsborough, T. Beppu, and K. Ueda. 2011.

Deinococcus depolymerans sp. nov., a gamma- and UV-radiation-resistant bacterium, isolated from a naturally radioactive site. Int. J. Syst. Evol. Microbiol. **61:**1448-1453.

Asker, D., T. S. Awad, T. Beppu, and K. Ueda. (2008) *Deinococcus misasensis* and *Deinococcus roseus,* novel members of the genus *Deinococcus*, isolated from a radioactive site in Japan. Syst. Appl. Microbiol. **31:**43-49.

Asker, D., T. S. Awad, T. Beppu, and K. Ueda. 2009. *Deinococcus aquiradiocola* sp. nov., isolated from a radioactive site in Japan. Int. J. Syst. Evol. Microbiol. **59:**144-149.

Asker, D., T.S. Awad, L. McLandsborough, T. Beppu, and K. Ueda. 2011. *Deinococcus depolymerans* sp. nov., a gamma- and UV-radiation-resistant bacterium, isolated from a naturally radioactive site. Int. J. Syst. Evol. Microbiol. **61:**1448-1453.

Avery, S. V. 2011. Molecular targets of oxidative stress. Biochemical J. **434:**201-210.

Bae, W., A. Mulchandani, and W. Chen. 2002. Cell surface display of synthetic phytochelatins using ice nucleation protein for enhanced heavy metal bioaccumulation. J. Inorg. Biochem. **88:**223-227.

Bae, W., R. K. Mehra, A. Mulchandani, and W. Chen. 2001. Genetic engineering of *Escherichia coli* for enhanced uptake and ioaccumulation of Mercury. Appl. Environ. Microbiol. **67:**5335-5338.

Bae, W., W. Chen, A. Mulchandani, and R. K. Mehra. 2000. Enhanced bioaccumulation of heavy metals by bacterial cells displaying synthetic phytochelatins. Biotechnol. Bioengin. **70:**518-524.

Barnese, K., E. B. Gralla, D. E. Cabelli, and J. Selverstone Valentine. 2008. Manganous phosphate acts as a superoxide dismutase. J. Am. Chem. Soc. **130:**4604-4606.

Battista, J. R. 1997. Against all odds: the survival strategies of *Deinococcus*

radiodurans. Annu. Rev. Microbiol. **51:**203-224.

Bauermeister, A., E. Bentchikou, R. Moeller, and P. Rettberg. 2009. Roles of PprA, IrrE, and RecA in the resistance of *Deinococcus radiodurans* to germicidal and environmentally relevant UV radiation. Arch. Microbiol.**191:**913–918

Bentchikou, E., P. Servant, G. v. Coste, and S. Sommer.2010. A Major Role of the RecFOR Pathway in DNA Double-Strand-Break Repair through ESDSA in *Deinococcus radiodurans*PLoS Genet **6:**e1000774.

Berlett, B. S., P. B. Chock, M. B. Yim, and E. R. Stadtman. 1990. Manganese(II) catalyzes the bicarbonate-dependent oxidation of amino acids by hydrogen peroxide and the amino acid-facilitated dismutation of hydrogen peroxide. Proc. Nat. Acad. Sci. **87:**389-393.

Billi, D., E. I. Friedmann, K. G. Hofer, M. G. Caiola, and R. Ocampo-Friedmann. 2000. Ionizing-radiation resistance in the desiccation-tolerant cyanobacterium *Chroococcidiopsis*. Appl. Environ. Microbiol. **66:**1489-1492.

Bjelland, S., and E. Seeberg. 2003. Mutagenicity, toxicity and repair of DNA base damage induced by oxidation. Mut. Res. **531:**37–80.

Blackwood, C. B., A. Oaks, and J. S. Buyer. 2005. Phylum- and class-specific PCR primers for general microbial community analysis. Appl. Environ. Microbiol. **71:**6193-6198.

Blasius, M., I. Shevelev, E. Jolivet, S. Sommer, and U. Hübscher. 2006. DNA polymerase X from *Deinococcus radiodurans* possesses a structure-modulated 3′→5′ exonuclease activity involved in radioresistance. Mol. Microbiol. **60:**165-176.

Blasius, M., S. Sommer and U. Hubscher. 2008. *Deinococcus radiodurans*: What belongs to the survival kit? Crit. Rev. Biochem. Mol. Biol. **43:**221–238

Blindauer, C. A., M. D. Harrison, J. A. Parkinson, A. K. Robinson, J. S. Cavet, N. J. Robinson, and P. J. Sadler. 2001. A metallothionein containing a

zinc finger within a four-metal cluster protects a bacterium from zinc toxicity. Proc. Natl. Acad. Sci. **98:**9593-9598.

Bonacossa de Almeida, C., G. Coste, S. Sommer, and A. Bailone. 2002. Quantification of RecA protein *Deinococcus radiodurans* reveals involvement of RecA, but not LexA, in its regulation. Mol. Genet. Genomics **268:**28-41.

Bradford, M. M. 1976. A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein dye binding. Anal. Biochem. **72:**248-254.

Brim, H., A. Venkateswaran, H. M. Kostandarithes, J. K. Fredrickson, and M. J. Daly. 2003. Engineering *Deinococcus geothermalis* for bioremediation of high-temperature radioactive waste environments. Appl. Environ. Microbiol. **69:**4575-4582.

Brim, H., J. P. Osborne, H. M. Kostandarithes, J. K. Fredrickson, L. P. Wackett, and M. J. Daly. 2006. *Deinococcus radiodurans* engineered for complete toluene degradation facilitates Cr (VI) reduction. Microbiol. **152:**2469-2477.

Brim, H., S. C. McFarlan, J. K. Fredrickson, K. W. Minton, M. Zhai, L. P. Wackett, and M. J. Daly. 2000. Engineering *Deinococcus radiodurans* for metal remediation in radioactive mixed waste environments. Nat. Biotech. **18:**85-90.

Brooks, B. W., and R. G. E. Murray. 1981. Nomenclature for "*Micrococcus radiodurans*" and other radiation-resistant cocci: *Deinococcaceae* fam. nov. and *Deinococcus* gen. nov., including five species. Int. J. Syst. Bacteriol. **31:**353-360.

Callegan, R. P., M. F. Nobre, P. M. McTernan, J. R. Battista, R. Navarro-Gonzalez, C. P. McKay, M. S. da Costa, and F. A. Rainey. 2008. Description of four novel psychrophilic, ionizing radiation-sensitive *Deinococcus* species from alpine environments. Int. J. Syst. Evol. Microbiol. **58:**1252-1258.

Cao, Z., C. W. Mueller, and D. A. Julin. 2010. Analysis of the recJ gene and protein from *Deinococcus radiodurans*. DNA Repair (Amst.) **9:**66–75.

Carpenter, E.J., S. Lin, and D. G. Capone. 2000. Bacterial activity in south pole snow. Appl. Environ. Microbiol. **66:**4514-4517.

Chakravarty, R., and P. Banerjee. 2008. Morphological changes in an acidophilic bacterium induced by heavy metals. Extremophiles **12:**279-284.

Chanal, A., V. Chapon, K. Benzerara, M. Barakat, R. Christen, W. Achouak, F. Barras, and T. Heulin. 2006. The desert of Tataouine: an extreme environment that hosts a wide diversity of microorganisms and radiotolerant bacteria. Environ. Microbiol. **8:**514-525.

Chao, Y. P., R. Patnaik, W. D. Roof, R. F. Young, and J. C. Liao. 1993. Control of gluconeogenic growth by pps and pck in *Escherichia coli*. J. Bacteriol. **175:**6939-6944.

Chen, H., G. Xu, Y. Zhao, B. Tian, H. Lu, X. Yu, Z. Xu, N. Ying, S. Hu, and Y. Hua. 2008. A Novel OxyR sensor and regulator of Hydrogen Peroxide stress with one cysteine residue in *Deinococcus radiodurans*. PLoS ONE **3:**e1602.

Chen, Y.-W., E. E. Dekker, and R. L. Somerville. 1995. Functional analysis of *E. coli* threonine dehydrogenase by means of mutant isolation and characterization. Biochimica et Biophysica Acta (BBA) - Protein Structure and Molecular Enzymology **1253:**208-214.

Chou, F. I., and S. T. Tan. 1990. Manganese (II) induces cell division and increases in superoxide dismutase and catalase activities in an aging deinococcal culture. J. Bacteriol. **172:**2029-2035.

Collins, M. D., R. A. Hutson, I. R. Grant, and M. F. Patterson. 2000.Phylogenetic characterization of a novel radiation-resistant bacterium from irradiated pork: description of Hymenobacter actinosclerus sp. nov. Int. J. Syst. Evol. Microbiol. **50:**731–734.

Counsell, T. J., and R. G. E. Murray. 1986. Polar lipid profiles of the genus *Deinococcus*. Int. J. Syst. Bacteriol. **36:**202-206.

Cox, M.M., and J. R. Battista. 2005. *Deinococcus radiodurans* – the consummate survivor. Nat. Rev. Microbiol. **3:**882-892.

Cuypers, A., M. Plusquin, T. Remans, M. Jozefczak, E. Keunen, H. Gielen, K. Opdenakker, A. Nair, E. Munters, T. Artois, T. Nawrot, J. Vangronsveld, and K. Smeets. 2010. Cadmium stress: an oxidative challenge. BioMetals **23:**927-940.

Daly, M. J 2000. Engineering radiation-resistant bacteria for environmental biotechnology. Curr. Opin. Biotechnol. **11:**280-285.

Daly, M. J., and K. W. Minton. 1996. An alternative pathway of recombination of chromosomal fragments precedes recA-dependent recombination in the radioresistant bacterium *Deinococcus radiodurans*. J. Bacteriol. **178:4461-4471**

Daly, M. J., E. K. Gaidamakova, V. Y. Matrosova, A. Vasilenko, M. Zhai, A. Venkateswaran, M. Hess, M. V. Omelchenko, H. M. Kostandarithes, K. S. Makarova, L. P. Wackett, J. K. Fredrickson, and D. Ghosal. 2004. Accumulation of Mn(II) in *Deinococcus radiodurans* facilitates gamma radiation resistance. Science **306:**1025-1028.

Daly, M. J., E. K. Gaidamakova, V. Y. Matrosova, A. Vasilenko, M. Zhai, R. D. Leapman, B. Lai, B. Ravel, S.-M. W. Li, K. M. Kemner, and J. K. Fredrickson. 2007. Protein oxidation implicated as the primary determinant of bacterial radioresistance. PLoS Biol **5:**e92.

Daly, M. J., E. K. Gaidamakova, V. Y. Matrosova, J. G. Kiang, R. Fukumoto, D. Y. Lee, N. B. Wehr, G. A. Viteri, B. S. Berlett, and R. L. Levine. 2010. Small molecule antioxidant proteome shields in *Deinococcus radiodurans.* PLoS ONE **5:**e12570.

Daly, M. J., O. Ling, and K. W. Minton. 1994. Interplasmidic recombination following irradiation of the radioresistant bacterium *Deinococcus radiodurans*. J. Bacteriol. **176:**7506–7515.

Daly, M.J. 2011. Death by protein damage in irradiated cells. DNA Repair. doi:10.1016/j.dnarep.2011.10.024.

Dandie, C. E., D. L. Burton, B. J. Zebarth, J. T. Trevors, and C. Goyer. 2007. Analysis of denitrification genes and comparison of nosZ, cnorB and 16S rDNA from culturable denitrifying bacteria in potato cropping systems. Syst. Appl. Microbiol. **30:**128-138.

Dar, S.A., L. Yao, U. van Dongen, J. G. Kuenen, and G. Muyzer. 2005. Analysis of diversity and activity of sulfate-reducing bacterial communities in sulfidogenic bioreactors using 16s RNA and dsr b genes as molecular markers. Appl. Environ. Microbiol. **73:**594-604.

Davis, N. S., G. J. Silverman, and E. B. Masurovsky. 1963. Radiation resistant, pigmented coccus isolated from haddock tissue. J. Bacteriol. **86:**294-298.

de Groot, A., V. Chapon, P. Servant, R. Christen, M. F. L. Saux, S. Sommer, and T. Heulin. 2005. *Deinococcus deserti* sp. nov., a gamma-radiation-tolerant bacterium isolated from the Sahara desert. Int. J. Syst. Evol. Microbiol. **55:**2441-2446.

D'Errico, G., A. Di Salle, F. La Cara, M. Rossi, and R. Cannio. 2006. Identification and characterization of a novel bacterial sulfite oxidase with no heme binding domain from *Deinococcus radiodurans*. J. Bacteriol. **188:**694-701.

Di Ruggiero, J., N. Santangelo, Z. Nackerdien, J. Ravel, and F. T. Robb. 1997. Repair of extensive ionizing-radiation DNA damage at 95 °C in the hyperthermophilic archaeon *Pyrococcus furiosus*. J. Bacteriol. **179:**4643–4645.

Dressler, C., U. Kues, D. H. Nies, and B. Friedrich. 1991. Determinants encoding resistance to several heavy metals in newly isolated Copper resistant bacteria. Appl. Environ. Microbiol. **57:**3079-3085.

Earl, A. M., M. M. Mohundro, I. S. Mian, and J. R. Battista. 2002a. The IrrE protein of *Deinococcus radiodurans* R1 is a novel regulator of recA expression. J. Bacteriol. **184:**6216-6224.

Earl, A. M., S. K. Rankin, K. P. Kim, O. N. Lamendola, and J. R. Battista. 2002b. Genetic evidence that the uvsE gene product of *Deinococcus radiodurans* R1 is a UV damage endonuclease. J. Bacteriol. **184:**1003-1009.

Evans, D. M., and B. E. Moseley. 1983. Roles of the uvsC, uvsD, uvsE, and mtcA genes in the two pyrimidine dimer excision repair pathways of *Deinococcus radiodurans*. J. Bacteriol. **156:**576-583.

Fanous, A., W. Weiss, A. Görg, F. Jacob, and H. Parlar. 2008. A proteome analysis of the cadmium and mercury response in *Corynebacterium glutamicum*. Proteomics **8:**4976-4986.

Farr, S. B., and T. Kogoma. 1991. Oxidative stress responses in *Escherichia coli* and *Salmonella typhimurium*. Microbiol. Rev. **55:**561-585.

Ferianc, P., A. Farewell, and T. Nystrom. 1998. The cadmium-stress stimulon of *Escherichia coli* K-12. Microbiology **144:**1045-1050.

Ferreira, A. C., M. F. Nobre, E. Moore, F. A. Rainey, J. R. Battista, and M. S. da Costa. 1999. Characterization and radiation resistance of new isolates of *Rubrobacter radiotolerans* and *Rubrobacter xylanophilus*. Extremophiles **3:**235-238.

Ferreira, A. C., M. F. Nobre, F. A. Rainey, M. T. Silva, R. Wait, J. Burghardt, A. P. Chung, and M. S. Da Costa. 1997. *Deinococcus geothermalis* sp. nov. and *Deinococcus murrayi* sp. nov., two extremely radiation-resistant and slightly thermophilic species from hot springs. Int. J. Syst. Bacteriol. **47:**939-947.

Fisher, D. I, J. L. Cartwright, and A. G. McLennan. 2006. Characterization of the Mn^{2+}stimulated (di) adenosine polyphosphate hydrolase encoded by the *Deinococcus radiodurans* DR2356 nudix gene. Arch. Microbiol. **186:**415-424.

Forster, L., Forster, P., Lutz-Bonengel, S., Willkomm, H. and Brinkmann, B. (2002). Natural radio activity and human mitochondrial DNA mutations. Proc. Nat. Acad. Sci. 99, 13950-13954.

Fredrickson, J. K., H. M. Kostandarithes, S. W. Li, A. E. Plymale, and M. J. Daly. 2000. Reduction of Fe(III), Cr(VI), U(VI), and Tc(VII) by *Deinococcus radiodurans* R1. Appl. Environ. Microbiol. **66:**2006-2011.

Fredrickson, J. K., J. M. Zachara, D. L. Balkwill, D. Kennedy, S. M. W. Li,

H. M. Kostandarithes, M. J. Daly, M. F. Romine, and F. J. Brockman. 2004. Geomicrobiology of high level nuclear waste contaminated Vadose sediments at the Hanford site, Washington state. Appl. Environ. Microbiol. **70:**4230-4241.

Fredriksson Å., Ballesteros, M., Dukan, S. and Nystrom, T. 2005. Defense against protein carbonylation by DnaK/DnaJ and proteases of the heat shock regulon. J. Bacteriol. **187:** 4207-4213.

Fridovich, I. 1995. Superoxide radical and superoxide dismutases. Annu. Rev. Biochem. **64:**97-112.

Funayama, T., et al. 1999. Identification and disruption analysis of the recN gene in the extremely radioresistant bacterium *Deinococcus radiodurans*. Mutat. Res. **435:**151–161.

Gallagher, S. 2001. Immunoblot detection. Curr. protocols in protein science. 10.10.1–10.10.12.

Ghosal, D., M. V. Omelchenko, E. K. Gaidamakova, V. Y. Matrosova, A. Vasilenko, A. Venkateswaran, M. Zhai, H. M. Kostandarithes, H. Brim, K. Makarova, L. P. Wackett, J. K. Fredrickson, and M. J. Daly. 2005. How radiation kills cells: Survival of *Deinococcus radiodurans* and *Shewanella oneidensis* under oxidative stress. FEMS Microbiol. Rev. **29:**361-375.

Gomes, N. C. M., L. R. Borges, R. Paranhos, F. N. Pinto, E. Kragerrecklenfort, L. C. S. Mendonca Hagler, and K. Smalla. 2007. Diversity of ndo genes in mangrove sediments exposed to different sources of polycyclic aromatic hydrocarbon pollution. Appl. Environ. Microbiol. **73:**7392-7399.

Green, P. N. and I. J. Bousfield. 1983. Emendation of *Methylobacterium* Patt, Cole, and Hanson 1976; *Methylobacterium rhodinum* (Heumann 1962) comb. nov. corrig.; *Methylobacterium radiotolerans* (Ito and Iizuka 1971) comb. nov. corrig.; and *Methylobacterium mesophilicum* (Austin and Goodfellow 1979) comb. nov. Int. J. Syst. Bacteriol. **33:**875–877.

Gutman, P. D., P. Fuchs, L. Ouyang, and K. W. Minton. 1993. Identification, sequencing, and targeted mutagenesis of a DNA polymerase gene required for the

extreme radio resistance of *Deinococcus radiodurans*. J. Bacteriol. **175:**3581-3590.

Hao, Z., H. R. Reiske, and D. B. Wilson. 1999. Characterization of Cadmium uptake in *Lactobacillus plantarum* and isolation of Cadmium and Manganese uptake mutants. Appl. Environ. Microbiol. **65:**4741-4745.

Harper, S., and D. W. Speicher. 2001. Detection of proteins on blot membranes. Curr. protocols in protein science. 10.8.1–10.8.7.

Harris, D. R., M. Tanaka, S. V. Saveliev, E. Jolivet, A. M. Earl, M. M. Cox, and J. R. Battista. 2004. Preserving genome integrity: the DdrA protein of *Deinococcus radiodurans* R1. PLoS Biol. **2:**e304.

Hastings, J. W., W. H. Holzapfel, and J. G. Niemand. 1986. Radiation resistance of lactobacilli isolated from radurized meat relative to growth and environment. Appl. Environ. Microbiol. **52:**898–901.

Helbig, K., C. Grosse, and D. H. Nies. 2008. Cadmium toxicity in glutathione mutants of *Escherichia coli*. J. Bacteriol. **190:**5439-5454.

Henke, W., K. Herdel, K. Jung, D. Schnorr, and S. Loening. 1997. Betaine improves the PCR amplification of GC-rich DNA sequences. Nucl. Acids Res. **25:**3957-3958.

Hirsch, P., C.A. Gallikowski, J. Siebert, K. Peissl, R. Kroppenstedt, P. Schumann, E. Stackebrandt, and R. Anderson. 2004. *Deinococcus frigens* sp. nov., *Deinococcus saxicola* sp. nov., and *Deinococcus marmoris* sp. nov., low temperature and draught-tolerating, UV-resistant bacteria from continental Antarctica. Syst. Appl. Microbiol. **27:**636-645.

Holland, A. D., H. M. Rothfuss, and M. E. Lidstrom. 2006. Development of a defined medium supporting rapid growth for *Deinococcus radiodurans* and analysis of metabolic capacities. Appl. Microbiol. Biotechnol. **72:**1074-1082.

Holmes, A. J., J. Bowyer, M. P. Holley, M. O'Donoghue, M. Montgomery, and M. R. Gillings. 2000. Diverse, yet-to-be-cultured members of the

Rubrobacter subdivision of the Actinobacteria are widespread in Australian arid soils. FEMS Microbiol. Ecol. **33:**111-120.

Holt, J. G., N. R. Krieg, P. H. Sneath, J. T. Staley, and S. T. Williams. 1997. Bergy's Manual of Determinative Bacteriology.

Horsburgh, M. J., S. J. Wharton, A. G. Cox, E. Ingham, S. Peacock, and S. J. Foster. 2002. MntR modulates expression of the PerR regulon and superoxide resistance in *Staphylococcus aureus* through control of manganese uptake. Mol. Microbiol. **44:**1269-1286.

Hosfield, D. J., Y. Guan, B. J. Haas, R. P. Cunningham, and J. A. Tainer. 1999. Structure of the DNA repair enzyme endonuclease IV and its DNA complex: Double-nucleotide flipping at a basic sites and three-metal-ion catalysis. Cell **98:**397-408.

Howlett, N. G., and S. V. Avery. 1997. Induction of lipid peroxidation during heavy metal stress in *Saccharomyces cerevisiae* and influence of plasma membrane fatty acid unsaturation. Appl. Environ. Microbiol. **63:**2971-6.

Hua, Y., I. Narumi, G. Gao, B. Tian, K. Satoh, S. Kitayama, and B. Shen. 2003. PprI: a general switch responsible for extreme radioresistance of *Deinococcus radiodurans*. Biochem. Biophys. Res. Commun. **306:**354-360.

Huang, L., et al. 2007. Three tandem HRDC domains have synergistic effect on the RecQ functions in *Deinococcus radiodurans*. DNA Repair (Amst.) **6:**167–176.

Huckle, J. W., A. P. Morby, J. S. Turner, and N. J. Robinson. 1993. Isolation of a prokaryotic metallothionein locus and analysis of transcriptional control by trace metal ions. Mol. Microbiol. **7:**177-187.

Im, W. T., H. M. Jung, L. N. Ten, M. K. Kim, N. Bora, M. Goodfellow, S. Lim, J. Jung, and S.-T. Lee. 2008. *Deinococcus aquaticus* sp. nov., isolated from fresh water, and *Deinococcus caeni* sp. nov., isolated from activated sludge. Int. J. Syst.ind Evol. Microbiol. **58:**2348-2353.

Imlay, J. A. 2003. Pathways of oxidative damage. Annu Rev Microbiol **57:**395-

418.

Imlay, J. A. 2008. Cellular defenses against superoxide and hydrogen peroxide. Annu. Rev. Biochem. **77**:755-776.

Imlay, J. A., and S. Linn. 1988. DNA damage and oxygen radical toxicity. Science **240**:1302-1309.

Ishihama, A. 1997. Adaptation of gene expression in stationary phase bacteria. Curr. Opin. Genet. Dev. **7**:582-588.

Jacobs, F. A., F. M. Romeyer, M. Beauchemin, and R. Brousseau. 1989. Human metallothionein-II is synthesized as a stable membrane-localized fusion protein in *Escherichia coli*. Gene **83**:95-103.

Jakubovics, N. S., and H. F. Jenkinson. 2001. Out of the iron age: new insights into the critical role of manganese homeostasis in bacteria. Microbiology **147**:1709-1718.

Joe MH, J. S., Im SH, Lim SY, Song HP, Kwon O, Kim DH. 2011. Genome-wide response of Deinococcus radiodurans on cadmium toxicity. J. Microbiol. Biotechnol. **21(4)**:438-47.

Jolivet, E., S. L'Haridon, E. Corre, P. Forterre, and D. Prieur. 2003. *Thermococcus gammatolerans* sp. nov., a hyperthermophilic archaeon from a deep-sea hydrothermal vent that resists ionizing radiation. Int. J. Syst. Evol. Microbiol. **53**:847–851.

Joshi, F., A. Chaudhari, P. Joglekar, G. Archana., and A. Desai. 2008. Effect of expression of *Bradyrhizobium japonicum* 61A152 *feg* A gene in *Mesorhizobium* sp., on its competitive survival and nodule occupancy on *Arachis hypogea.* Appl. Soil Ecol. **40**:338-347

Jurado, M., C. Vazquez, S. Marin, V. Sanchis, and M. Teresa Gonzalez Jaen. 2006. PCR-based strategy to detect contamination with mycotoxigenic Fusarium species in maize. Syst. Appl. Microbiol. **29**:681-689.

Kaakoush, N. O., M. Raftery, and G. L. Mendz. 2008. Molecular responses of *Campylobacter jejuni* to cadmium stress. FEBS Journal **275:**5021-5033.

Kampfer, P. 2009. *Deinococcus mumbaiensis* Shashidhar and Bandekar 2006 is a later heterotypic synonym of *Deinococcus ficus* Lai et al. 2006. Int. J. Syst. Evol. Microbiol. **59:**365-366.

Kampfer, P., N. Lodders, B. Huber, E. Falsen, and H. J. R. Busse. 2008. Deinococcus aquatilis sp. nov., isolated from water. Int. J. Syst. Evol. Microbiol. **58:**2803-2806.

Kehres, D. G., and M. E. Maguire. 2003. Emerging themes in manganese transport, biochemistry and pathogenesis in bacteria. FEMS Microbiol. Rev. **27:**263-290.

Khairnar, N. P., H. S. Misra, and S. K. Apte. 2003. Pyrroloquinolinequinone synthesized in *Escherichia coli* by pyrroloquinoline-quinone synthase of *Deinococcus radiodurans* plays a role beyond mineral phosphate solubilization. Biochem. Biophys. Res. Commun. **312:**303–308.

Kim, B. Y., J. D. Kshetrimayum, and M. Goodfellow. 2011. Detection, selective isolation and characterisation of *Dactylosporangium* strains from diverse environmental samples. Syst. Appl. Microbiol. **34:**606-616.

Kitayama, S., I. Narumi, M. Kikuchi, and H. Watanabe. 2000. Mutation in recR gene of *Deinococcus radiodurans* and possible involvement of its product in the repair of DNA interstrand cross-links. Mutat. Res. **461:**179– 187.

Klocke, M., K. Mundt, C. Idler, J. McEniry, P. O.Kiely, and S. Barth. 2006. Monitoring *Lactobacillus plantarum* in grass silages with the aid of 16S rDNA-based quantitative real-time PCR assays. Syst. Appl. Microbiol. **29:**49-58.

Kobayashi, I., T. Tamura, H. Sghaier, I. Narumi, S. Yamaguchi, K. Umeda, and K. Inagaki. 2006. Characterization of monofunctional catalase KatA from radioresistant bacterium *Deinococcus radiodurans*. J. Biosci. Bioeng. **101:**315-321.

Koski, L. B., and G. B. Golding. 2001. The closest BLAST hit is often not the nearest neighbor. J. Mol. Evol. **52:**540-542.

Kota, S., and H. Misra. 2006. PprA: a protein implicated in radioresistance of;*Deinococcus radiodurans;* stimulates catalase activity in ;*Escherichia coli.* Appl. Microbiol. Biotechnol. **72:**790-796.

Kota, S., and H. S. Misra. 2008. Identification of a DNA processing complex from *Deinococcus radiodurans*. Biochem. Cell Biol. **86:**448-458.

Kotrba, P., L. Doleckova, V. C. de Lorenzo, and T. Ruml. 1999a. Enhanced bioaccumulation of heavy metal ions by bacterial cells due to surface display of short metal binding peptides. Appl. Environ. Microbiol. **65:**1092-1098.

Kotrba, P., P. Pospisil, V. de Lorenzo, and T. Ruml. 1999b. Enhanced metallosorption of *Escherichia coli* cells due to surface display of α- and β - domains of mammalian metallothionein as a fusion to lamb protein. J. Recept Signal Transduct. Res. **19:**703-715.

Kottemann, M., A. Kish, C. Iloanusi, S. Bjork, and J. DiRuggiero. 2005. Physiological responses of the halophilic archaeon *Halobacterium* sp. strain NRC1 to desiccation and gamma irradiation. Extremophiles **9:**219–227.

Krisko, A., and M. Radman. 2010. Protein damage and death by radiation in *Escherichia coli* and *Deinococcus radiodurans*. Proc. Natl. Acad. Sci. U S A

Kuzminov, A. 1999. Recombinational repair of DNA damage in *Escherichia coli* and bacteriophage lambda. Microbiol. Mol. Biol. Rev. **63:**751-813.

Laddaga, R. A., and S. Silver. 1985. Cadmium uptake in *Escherichia coli* K-12. J. Bacteriol. **162:**1100-1105.

Lai, W. A., P. KÃmpfer, A. B. Arun, F.-T. Shen, B. Huber, P. D. Rekha, and C. C. Young. 2006. *Deinococcus ficus* sp. nov., isolated from the rhizosphere of *Ficus religiosa* L. Int. J. Syst. Evol. Microbiol. **56:**787-791.

Lange, C. C., L. P. Wackett, K. W. Minton, and M. J. Daly. 1998. Engineering a recombinant *Deinococcus radiodurans* for organo pollutant degradation in radioactive mixed waste environments. Nat. Biotech. **16:**929-933.

Lee, Y. S. Y. a. Y. N. 2003. Production of superoxide dismutase by *Deinococcus radiophilus*. J. Biochem. Mol. Biol. **36:**282-287.

Levin-Zaidman, S., J. Englander, E. Shimoni, A. K. Sharma, K. W. Minton, and A. Minsky. 2003. Ring like Structure of the *Deinococcus radiodurans* genome: A Key to Radioresistance? Science **299:**254-256.

Lewis, N. F. 1971. Studies on a radio-resistant coccus isolated from Bombay duck (*Harpodon nehereus*). J. Gen. Microbiol. **66:**29-35.

Lin, C. L., C. S. Lin, and S. T. Tan. 1995. Mutations showing specificity for normal growth or Mn(II)-dependent post-exponential-phase cell division in *Deinococcus radiodurans*. Microbiology **141:**1707-1714.

Lin, J., R. Qi, C. Aston, J. Jing, T. S. Anantharaman, B. Mishra, O. White, M. J. Daly, K. W. Minton, J. C. Venter, and D. C. Schwartz. 1999. Whole genome shotgun optical mapping of *Deinococcus radiodurans*. Science **285:**1558-1562.

Lipton, M. S., L. Pasa-Tolic, G. A. Anderson, D. J. Anderson, D. L. Auberry, J. R. Battista, M. J. Daly, J. Fredrickson, K. K. Hixson, H. Kostandarithes, C. Masselon, L. M. Markillie, R. J. Moore, M. F. Romine, Y. Shen, E. Stritmatter, N. ToliÄ, H. R. Udseth, A. Venkateswaran, K.K. Wong, R. Zhao, and R. D. Smith. 2002. Global analysis of the *Deinococcus radiodurans* proteome by using accurate mass tags. Proc. Natl. Acad. Sci. **99:**11049-11054.

Liu, Y., J. Zhou, M. V. Omelchenko, A. S. Beliaev, A. Venkateswaran, J. Stair, L. Wu, D. K. Thompson, D. Xu, I. B. Rogozin, E. K. Gaidamakova, M. Zhai, K. S. Makarova, E. V. Koonin, and M. J. Daly. 2003. Transcriptome dynamics of *Deinococcus radiodurans* recovering from ionizing radiation. Proc. Nat. Acad. Sci. **100:**4191-4196.

Makarova, K. S., L. Aravind, N. V. Grishin, I. B. Rogozin, and E. V. Koonin.

2002. A DNA repair system specific for thermophilic Archaea and bacteria predicted by genomic context analysis. Nucleic Acids Res. **30:**482-496.

Makarova, K. S., L. Aravind, Y. I. Wolf, R. L. Tatusov, K. W. Minton, E. V. Koonin, and M. J. Daly. 2001. Genome of the extremely radiation resistant bacterium *Deinococcus radiodurans* viewed from the perspective of comparative genomics. Microbiol. Mol. Biol. Rev. **65:**44-79.

Makarova, K. S., M. V. Omelchenko, E. K. Gaidamakova, V. Y. Matrosova, A. Vasilenko, M. Zhai, A. Lapidus, A. Copeland, E. Kim, M. Land, K. Mavromatis, S. Pitluck, P. M. Richardson, C. Detter, T. Brettin, E. Saunders, B. Lai, B. Ravel, K. M. Kemner, Y. I. Wolf, A. Sorokin, A. V. Gerasimova, M. S. Gelfand, J. K. Fredrickson, E. V. Koonin, and M. J. Daly. 2007. *Deinococcus geothermalis*: The pool of extreme radiation resistance genes shrinks. PLoS ONE **2:**e955.

Makui, H., E. Roig, S. T. Cole, J. D. Helmann, P. Gros, and M. F. M. Cellier. 2000. Identification of the *Escherichia coli* K-12 Nramp orthologue (MntH) as a selective divalent metal ion transporter. Mol. Microbiol. **35:**1065-1078.

Markillie, L. M., S. M. Varnum, P. Hradecky, and K.-K. Wong. 1999. Targeted mutagenesis by duplication insertion in the radioresistant bacterium *Deinococcus radiodurans*: Radiation sensitivities of catalase (katA) and superoxide dismutase (sodA) mutants. J. Bacteriol. **181:**666-669.

Marklund, S., and G. Marklund. 1974. Involvement of the superoxide anion radical in the autoxidation of Pyrogallol and a convenient assay for superoxide Dismutase. Eur. J. Biochem. **47:**469-474.

Martinez, A., and R. Kolter. 1997. Protection of DNA during oxidative stress by the nonspecific DNA-binding protein Dps. J. Bacteriol. **179:**5188-94.

Martins, A., and S. Shuman. 2004. An RNA ligase from *Deinococcus radiodurans*. J. Biol. Chem. **279:**50654-50661.

Massalski, A., V. M. Laube, and D. J. Kushner. 1981. Effects of cadmium and copper on the ultrastructure of *;Ankistrodesmus braunii ;Anabaena* 7120. Micro.

Ecol. 7:183-193.

Malin, M. and L. Bülow. 2001. Metal-binding proteins and peptides in bioremediation and phytoremediation of heavy metals. Trends Biotechnol. **19 :** 67-73.

Massalski, A., V. M. Laube., and D. J. Kushner. 1981. Effects of Cadmium and Copper on the ultrastructure of *Ankistrodesmus braunii* and *Anabaena* 7120. Microbial Ecol. **7:**183-193.

Masters, C. I., R. G. E. Murray, B. E. B. Moseley, and K. W. Minton. 1991. DNA polymorphisms in new isolates of '*Deinococcus radiopugnans*'. J. Gen. Microbiol. **137:**1459-1469.

Mauro, J. M., and M. Pazirandeh. 2000. Construction and expression of functional multi-domain polypeptides in *Escherichia coli*: expression of the *Neurospora crassa* metallothionein gene. Lett. Appl. Microbiol. **30:**161-166.

Meima, R., and M. Lidstrom. 2000. Characterization of the minimal replicon of a cryptic *Deinococcus radiodurans* SARK plasmid and development of versatile *Escherichia coli D. radiodurans* shuttle vectors. Appl. Environ. Microbiol. **66:**3856-3867.

Mejare, M., S. Ljung, and L. Bulow. 1998. Selection of cadmium specific hexapeptides and their expression as OmpA fusion proteins in *Escherichia coli.* Protein Eng. **11:**489-494.

Miller, J. H. 1982. Experiments in molecular biology. Cold Spring Harbor Laboratory Press, Cold Spring Harbor, N.Y.

Minton, K. W. 1994. DNA repair in the extremely radioresistant bacterium *Deinococcus radiodurans.* Mol. Microbiol. **13:**9–15.

Misra, H. S., N. P. Khairnar, A. Barik, K. Indira Priyadarsini, H. Mohan, and S. K. Apte. 2004. Pyrroloquinoline-quinone: a reactive oxygen species scavenger in bacteria. FEBS Lett. **578:**26-30.

Missiakas, D., and S. Raina. 1997. Signal transduction pathways in response to protein misfolding in the extra cytoplasmic compartments of *E.coli*: role of two

new phosphoprotein phosphatases PrpA and PrpB. EMBO J. **16:**1670-1685.

Mitra, R. S. 1984. Protein synthesis in *Escherichia coli* during recovery from exposure to low levels of Cd^{2+}. Appl. Environ. Microbiol. **47:**1012-1016.

Moeller, R., et al. 2010. Genomic bipyrimidine nucleotide frequency and microbial reactions to germicidal UV radiation. Arch. Microbiol. **192:**521– 529.

Moseley, B. E. B., and D. M. Evans. 1983. Isolation and properties of strains of *Micrococcus* (*Deinococcus*) *radiodurans* unable to excise ultraviolet light-induced pyrimidine dimers from DNA: Evidence for two excision pathways. J. Gen. Microbiol. **129:**2437-2445.

Muhling, M., J. Woolven Allen, J. C. Murrell, and I. Joint. 2008. Improved group-specific PCR primers for denaturing gradient gel electrophoresis analysis of the genetic diversity of complex microbial communities. ISME J. **2:**379-392.

Mukhopadhyay, B., S. F. Stoddard, and R. S. Wolfe. 1998. Purification, Regulation, and Molecular and Biochemical Characterization of Pyruvate Carboxylase from Methanobacterium thermoautotrophicum Strain Î"H. Journal of Biological Chemistry **273:**5155-5166.

Muyzer, G., E. C. de Waal, and A. G. Uitterlinden. 1993. Profiling of complex microbial populations by denaturing gradient gel electrophoresis analysis of polymerase chain reaction-amplified genes coding for 16S rRNA. Appl. Environ. Microbiol. 59,695-700.

Narumi, I., K. Satoh, S. Cui, T. Funayama, S. Kitayama, and H. Watanabe. 2004. PprA: a novel protein from *Deinococcus radiodurans* that stimulates DNA ligation. Mol. Microbiol. **54:**278-285.

Neidhart, D. J., G. L. Kenyon, J. A. Gerlt, and G. A. Petsko. 1990. Mandelate racemase and muconate lactonizing enzyme are mechanistically distinct and structurally homologous. Nature **347:**692-694.

Nies, D. H. 1999. Microbial heavy-metal resistance. Appl. Microbiol. Biotechnol. **51:**730-750.

Nishimura, Y., T. Ino, and H. Iizuka. 1988. *Acinetobacter radioresistens* sp. nov. isolated from cotton and soil. Int. J. Syst. Bacteriol. **38:**209–211.

Nystrom, T. 2004. Stationary phase physiology. Annu. Rev. Microbiol. **58:**161-181.

Obiero, J., V. Pittet, S. A. Bonderoff, and D. A. R. Sanders. 2010. Thioredoxin System from *Deinococcus radiodurans*. J. Bacteriol. **192:**494-501.

Ohba, H., K. Satoh, H. T. Sghaier, T. Yanagisawa, and I. Narumi. 2009. Identification of PprM: a modulator of the PprI-dependent DNA damage response in *Deinococcus radiodurans*. Extremophiles **13:**471-479.

Ohba, H., K. Satoh, T. Yanagisawa, and I. Narumi. 2005. The radiation responsive promoter of the *Deinococcus radiodurans* pprA gene. Gene **363:**133-141.

Ohtani, N., M. Haruki, A. Muroya, M. Morikawa, and S. Kanaya. 2000. Characterization of ribonuclease HII from *Escherichia coli* overproduced in a soluble form. J. Biochem. **127:**895-899.

Ohtani, N., M. Haruki, M. Morikawa, R. J. Crouch, M. Itaya, and S. Kanaya. 1998. Identification of the genes encoding Mn2+-dependent RNase H II and Mg2+-dependent RNase H III from *Bacillus subtilis*: Classification of RNases H into three families. Biochemistry **38:**605-618.

Olafson, R. W., W. D. McCubbin, and C. M. Kay. 1988. Primary and secondary structural analysis of a unique prokaryotic metallothionein from a *Synechococcus* sp. cyanobacterium. Biochem. J. **251:**691-699.

Omelchenko, M., Y. Wolf, E. Gaidamakova, V. Matrosova, A. Vasilenko, M. Zhai, M. Daly, E. Koonin, and K. Makarova. 2005. Comparative genomics of *Thermus thermophilus* and *Deinococcus radiodurans*: divergent routes of adaptation to thermophily and radiation resistance. BMC Evol. Biol. **5:**57.

Park, S., and J. A. Imlay. 2003. High levels of intracellular cysteine promote oxidative DNA damage by driving the Fenton reaction. J. Bacteriol. **185:**1942-

1950.

Pazirandeh, M., B. M. Wells, and R. L. Ryan. 1998. Development of bacterium based heavy metal biosorbents: Enhanced uptake of Cadmium and Mercury by *Escherichia coli* expressing a metal binding motif. Appl. Environ. Microbiol. **64:**4068-4072.

Peltola, M., C. K. Öqvist, J. Ekman, M. Kosonen, S. Jokela, M. Kolari, P. Korhonen, M. Salkinoja Salonen. 2008. Quantitative contributions of bacteria and of *Deinococcus geothermalis* to deposits and slimes in paper industry. J. Ind. Microbiol. Biotechnol. **35:**1651-1657.

Peng, F., L. Zhang, X. Luo, J. Dai, H. An, Y. Tang, and C. Fang. 2009. *Deinococcus xinjiangensis* sp. nov., isolated from desert soil. Int. J. Syst. Evol. Microbiol. **59:**709-713.

Perez, J. M., I. n. L. CalderÃ³n, F. A. Arenas, D. E. Fuentes, G. A. Pradenas, E. L. Fuentes, J. M. Sandoval, M. E. Castro, A. O. ElÃas, and C. C. VÃ¡squez. 2007. Bacterial toxicity of potassium tellurite: Unveiling an ancient enigma. PLoS ONE **2:**e211.

Perfumo, A., C. Cockell, A. Elsaesser, R. Marchant, and G. Kminek. 2011. Microbial diversity in Calamita ferromagnetic sand. Environ. Microbiol. Reports 3:483-490.

Pilhofer, M., M. Pavlekovic, N. M. Lee, W. Ludwig, and K. H. Schleifer. 2009. Fluorescence in situ hybridization for intracellular localization of nifH mRNA. Syst. Appl. Microbiol. **32:**186-192.

Porteous, L.A., R. J. Seidler, and L. S. Watrud. 1997. An improved method for purifying DNA from soil for polymerase chain reaction amplification and molecular ecology applications. Mol. Ecol. **6:**787-791.

Pradhan , S., T. N. R. Srinivas, P. K. Pindi, K. H. Kishore, Z. Begum, P. K. Singh, A. K. Singh, M. S. Pratibha, A. K. Yasala, G. S. N. Reddy and S. Shivaji. 2010. Bacterial biodiversity from Roopkund Glacier, Himalayan mountain ranges, India. Extremophiles **14:**377-395.

Pulawska, J., A. Willems, and P. Sobiczewski. 2006. Rapid and specific identification of four *Agrobacterium* species and bio vars using multiplex PCR. Syst. Appl. Microbiol. **29:**470-479.

Qin, J., L. Song, H. Brim, M. J. Daly, and A. O. Summers. 2006. Hg(II) sequestration and protection by the MerR metal-binding domain (MBD). Microbiology **152:**709-719.

Raina, S., and D. Missiakas. 1997. Making and breaking disulfide bonds. Annu. Rev. Microbiol. **51:**179-202.

Rainey, F. A., K. Ray, M. Ferreira, B. Z. Gatz, M. F. Nobre, D. Bagaley, B. A. Rash, M.-J. Park, A. M. Earl, N. C. Shank, A. M. Small, M. C. Henk, J. R. Battista, P. KÃ¤mpfer, and M. S. da Costa. 2005. Extensive diversity of ionizing-radiation-resistant bacteria recovered from Sonoran desert soil and description of nine new Species of the genus *Deinococcus* obtained from a single soil sample. Appl. Environ. Microbiol. **71:**5225-5235.

Rainey, F. A., M. F. Nobre, P. Schumann, E. Stackebrandt, and M. S. da Costa. 1997. Phylogenetic diversity of the Deinococci as determined by 16S ribosomal DNA sequence comparison. Int. J. Syst. Bacteriol. **47:**510-514.

Rainey, F. A., M. Ferreira, M. F. Nobre, K. Ray, D. Bagaley, A. M. Earl, J. R. Battista, B. Gomez-Silva, C. P. McKay, and M. S. da Costa. 2007. *Deinococcus peraridilitoris* sp. nov., isolated from a coastal desert. Int. J. Syst. Evol. Microbiol. **57:** 1408-1412.

Rajpurohit, Y. S., R. Gopalakrishnan, and H. S. Misra. 2008. Involvement of a protein kinase activity inducer in DNA double strand break repair and radioresistance of *Deinococcus radiodurans*. J. Bacteriol. **190:**3948-3954.

Rao, N. N., S. Liu, and A. Kornberg. 1998. Inorganic polyphosphate in *Escherichia coli*: the phosphate regulon and the stringent response. J. Bacteriol. **180:**2186-2193.

Rastogi, G., O. Shariff, P. A. Vaishampayan, G. L. Andersen, L. D. Stetler, and R. K. Sani. 2010. Microbial Diversity in Uranium mining impacted soils as

revealed by high density 16S microarray and clone library. Microb. Ecol. **59:**94–108.

Rosen B. P. 2002. Transport and detoxification systems for transition metals, heavy metals and metalloids in eukaryotic and prokaryotic microbes. Comp. Biochem. Physiol A Mol Integr Physiol. **133:**689-693.

Rothfuss, H., J. C. Lara, A. K. Schmid, and M. E. Lidstrom. 2006. Involvement of the S-layer proteins Hpi and SlpA in the maintenance of cell envelope integrity in Deinococcus radiodurans R1. Microbiology **152:**2779-2787.

Rothkamm, K., and M. Lobrich. 2003. Evidence for a lack of DNA doublestrand break repair in human cells exposed to very low X-ray doses. Proc. Natl. Acad. Sci. **100:**5057–5062.

Roy, R., A. L. Menon, and M. W. Adams. 2001. Aldehyde oxido reductases from *Pyrococcus furiosus*. Methods Enzymol. **331:**132 - 144.

Ruggiero, C. E., H. Boukhalfa, J. H. Forsythe, J. G. Lack, L. E. Hersman, and M. P. Neu. 2005. Actinide and metal toxicity to prospective bioremediation bacteria. Environ. Microbiol. **7:**88-97.

Sambrook, J., and D. Russell. 2001. Molecular cloning: a laboratory manual, 3rd ed. Cold Spring Harbor Laboratory Press, Cold Spring Harbor, N.Y.

Satoh, K., H. Ohba, H. T. Sghaier, and I. Narumi. 2006. Down-regulation of radioresistance by LexA2 in *Deinococcus radiodurans*. Microbiology **152:**3217-3226.

Satoh, K., Z. Tu, H. Ohba, and I. Narumi. 2009. Development of versatile shuttle vectors for *Deinococcus grandis*. Plasmid **62:**1-9.

Sauer, U., F. Canonaco, S. Heri, A. Perrenoud, and E. Fischer. 2004. The soluble and membrane-bound trans hydrogenases UdhA and PntAB have divergent functions in NADPH metabolism of *Escherichia coli*. J. Biol. Chem. **279:**6613-6619.

Schmid, A. K., H. A. Howell, J. R. Battista, S. N. Peterson, and M. E.

Lidstrom. 2005. Global transcriptional and proteomic analysis of the Sig1 heat shock regulon of *Deinococcus radiodurans*. J. Bacteriol. **187:**3339-3351.

Seemann, J. E., and G. E. Schulz. 1997. Structure and mechanism of l-fucose isomerase from *Escherichia coli*. J. Mol. Biol. **273:**256-268.

Seemann, J. E., and G. E. Schulz. 1997. Structure and mechanism of l-fucose isomerase from Escherichia coli. Journal of Molecular Biology **273:**256-268.

Sekowska, A., A. Danchin, and J.-L. Risler. 2000. Phylogeny of related functions: the case of polyamine biosynthetic enzymes. Microbiology **146:**1815-1828.

Semchyshyn, H., T. Bagnyukova, K. Storey, and V. Lushchak. 2005. Hydrogen peroxide increases the activities of soxRS regulon enzymes and the levels of oxidized proteins and lipids in *Escherichia coli*. Cell Bio. Int. **29:**898-902.

Seo, H. J., and Y. N. Lee. 2006. Occurrence of thioredoxin reductase in Deinococcus species, the UV resistant bacteria. J. Microbiol. **44:**461–465.

Shadrick, W. R., and D. A. Julin. 2010. Kinetics of DNA unwinding by the RecD2 helicase from *Deinococcus radiodurans*. J. Biol. Chem. **285:**17292–17300.

Shashidhar, R., and J. R. Bandekar. 2006. *Deinococcus mumbaiensis* sp. nov., a radiation-resistant pleomorphic bacterium isolated from Mumbai, India. FEMS Microbiol. Lett. **254:**275-280.

Shashidhar, R., and J. R. Bandekar. 2009. *Deinococcus piscis* sp. nov., a radiation-resistant bacterium isolated from a marine fish. Int. J. Syst. Evol. Microbiol. **59:**2714-2717.

Shashidhar, R., S. A. Kumar, H. S. Misra, and J. R. Bandekar. 2010. Evaluation of the role of enzymatic and nonenzymatic antioxidant systems in the radiation resistance of *Deinococcus*. Can. J. Microbiol. **56:**195-201.

Sheng, D., M. Li, J. Jiao, X. Sheng, W. Deng, and Y. Hua. 2005. Repression of

recA induction by RecX is independent of the RecA protein in *Deinococcus radiodurans*. J. Bacteriol. **192:**3540-3544.

Shukla, M., R. Chaturvedi, D. Tamhane, P. Vyas, G. Archana, S. Apte, J. Bandekar, and A. Desai. 2007. Multiple-stress tolerance of ionizing radiation-resistant bacterial isolates obtained from various habitats: Correlation between stresses. Curr. Microbiol. **54:**142-148.

Silver, S., and L. Phung. 2005. A bacterial view of the periodic table: genes and proteins for toxic inorganic ions. J. Ind. Microbiol. Biotechnol. **32:**587-605.

Singh, S. P., and A. K. Pandey. 1981. Cadmium toxicity in a cyanobacterium: Effect on modifying factors. Environ. Exp. Botany **21:**257-265.

Slade, D., A. B. Lindner, G. Paul, and M. Radman. 2009. Recombination and replication in DNA repair of heavily irradiated *Deinococcus radiodurans*. Cell **136:**1044-1055.

Slade, D., and M. Radman. 2011. Oxidative Stress Resistance in *Deinococcus* radiodurans. Microbiol. Mol. Biol. Rev. **75:**133-191.

Sousa, C., A. Cebolla, and V. de Lorenzo. 1996. Enhanced metalloadsorption of bacterial cells displaying poly-His peptides. Nat. Biotech. **14:**1017-1020.

Sousa, C., P. Kotrba, T. Ruml, A. Cebolla, and V. c. De Lorenzo. 1998. Metalloadsorption by *Escherichia coli* cells displaying yeast and mammalian metallothioneins anchored to the outer membrane protein LamB. J. Bacteriol. **180:**2280-2284.

Stadtman, E. R. 2006. Protein oxidation and aging. Free Radical Res. **40:**1250-1258.

Stohs, S. J., and D. Bagchi. 1995. Oxidative mechanisms in the toxicity of metal ions. Free Radic. Bio. Med. **18:**321-336.

Suen, G., B. S. Goldman, and R. D. Welch. 2007. Predicting prokaryotic ecological niches using genome sequence analysis. PLos ONE **2**(8): e743.

Sun, Z., S. Shen, C. Wang, H. Wang, Y. Hu, J. Jiao, T. Ma, B. Tian, and Y. Hua. 2009. A novel carotenoid 1,2-hydratase (CruF) from two species of the non-photosynthetic bacterium *Deinococcus*. Microbiology **155:**2775-2783.

Suresh, K., G. S. N. Reddy, S. Sengupta, and S. Shivaji. 2004. Deinococcus indicus sp. nov., an arsenic-resistant bacterium from an aquifer in West Bengal, India. Int. J. Syst. Evol. Microbiol. **54:**457-461.

Tanaka, A., H. Hirano, M. Kikuchi, S. Kitayama, and H. Watanabe. 1996. Changes in cellular proteins of *Deinococcus radiodurans* following irradiation. Radiat. Environ. Biophys **35:**95-99.

Tanaka, M., A. M. Earl, H. A. Howell, M. J. Park, J. A. Eisen, S. N. Peterson, and J. R. Battista. 2004. Analysis of *Deinococcus radiodurans's* transcriptional response to ionizing radiation and desiccation reveals novel proteins that contribute to extreme radioresistance. Genetics **168:**21-33.

Tanaka, M., I. Narumi, T. Funayama, M. Kikuchi, H. Watanabe, T. Matsunaga, O. Nikaido, and K. Yamamoto. 2005. Characterization of pathways dependent on the uvsE, uvrA1, or uvrA2 gene product for UV resistance in *Deinococcus radiodurans*. J. Bacteriol. **187:**3693-3697.

Táncsics A., I. Szabó, E. Baka, S. Szoboszlay, J. Kukolya, B. Kriszt, and K. Márialigeti. 2010. Investigation of catechol 2,3-dioxygenase and 16S rRNA gene diversity in hypoxic, petroleum hydrocarbon contaminated groundwater. Syst. Appl. Microbiol. **33:**398-406.

Thomas, N. 1999. Starvation, cessation of growth and bacterial aging. Curr. Opin. Microbiol. **2:**214-219.

Thompson, J., S. B. Ruvinov, D. N. I. Freedberg, and B. G. Hall. 1999. Cellobiose-6-phosphate hydrolase (CelF) of *Escherichia coli*: Characterization and assignment to the unusual family 4 of glycosylhydrolases. J. Bacteriol. **181:**7339-7345.

Thompson, M. J., and D. Eisenberg. 1999. Transproteomic evidence of a loop-deletion mechanism for enhancing protein thermostability. J. Mol. Biol. **290:**595-

604.

Tian, B., Z. Sun, S. Shen, H. Wang, J. Jiao, L. Wang, Y. Hu, and Y. Hua. 2009. Effects of carotenoids from *Deinococcus radiodurans* on protein oxidation. Lett. Appl. Microbiol. **49:**689-694.

Tian, B., Z. Sun, Z. Xu, S. Shen, H. Wang, and Y. Hua. 2008. Carotenoid desaturase is involved in carotenoid biosynthesis in the radioresistant bacterium *Deinococcus radiodurans*. Microbiology **154:**3697-3706.

Tsaneva, I. R., B. Muller, and S. C. West. 1993. RuvA and RuvB proteins of *Escherichia coli* exhibit DNA helicase activity in vitro. Proc. Natl. Acad. Sci. U. S. A. **90:**1315–1319.

Turner, J. S., A. P. Morby, B. A. Whitton, A. Gupta, and N. J. Robinson. 1994. Construction of Zn^{2+}/Cd^{2+} hypersensitive cyanobacterial mutants lacking a functional metallothionein locus. J. Biol. Chem. **268:**4494-8.

Unyayar, S., A. Celik, F. Ozlem, and A. Gozel. 2006. Cadmium-induced genotoxicity, cytotoxicity and lipid peroxidation in *Allium sativum* and *Vicia faba*. Mutagenesis **21:**77-81.

Vaituzis, Z., J. D. Nelson, L. W. Wan, and R. R. Colwell. 1975. Effects of mercuric chloride on growth and morphology of selected strains of mercury resistant bacteria. Appl. Microbiol. **29:**275-286.

Vaituzis. Z., J. D. Nelson Jr,.l. W. Wan, and R. R Colwell. 1975. Effects of Mercuric Chloride on growth and morphology of selected strains of Mercury resistant bacteria. Appl. Microbiol. **29:**275-286.

Valls, M., R. Gonzalez-Duarte, S. Atrian, and V. De Lorenzo. 1998. Bioaccumulation of heavy metals with protein fusions of metallothionein to bacteriol OMPs. Biochimie **80:**855-861.

van Gerwen, S. J., F. M. Rombouts, K. van't Riet, and M. H. Zwietering. 1999. A data analysis of the irradiation parameter D_{10} for bacteria and spores under various conditions. J. Food Prot. **62:**1024–1032.

Venkateswaran, A., S. C. McFarlan, D. Ghosal, K. W. Minton, A. Vasilenko, K. Makarova, L. P. Wackett, and M. J. Daly. 2000. Physiologic determinants of radiation resistance in *Deinococcus radiodurans*. Appl. Environ. Microbiol. **66:**2620-2626.

Vido, K., D. Spector, G. Lagniel, S. Lopez, M. B. Toledano, and J. Labarre. 2001. A Proteome analysis of the Cadmium response in *Saccharomyces cerevisiae*. J. Biol. Chem. **276:**8469-8474.

Waldron, K. J., and N. J. Robinson. 2009. How do bacterial cells ensure that metalloproteins get the correct metal? Nat. Rev. Micro. **7:**25-35.

Wang, A., and D. E. Crowley. 2005. Global gene expression responses to Cadmium toxicity in *Escherichia coli*. J. Bacteriol. **187:**3259-3266.

Wang, L., G. Xu, H. Chen, Y. Zhao, N. Xu, B. Tian, and Y. Hua. 2008. DrRRA: a novel response regulator essential for the extreme radioresistance of *Deinococcus radiodurans*. Mol. Microbiol. **67:**1211-1222.

Wang, P., and H. E. Schellhorn. 1995. Induction of resistance to hydrogen peroxide and radiation in *Deinococcus radiodurans*. Can. J. Microbiol. **41:**170-176.

Wang, W., J. Mao, Z. Zhang, Q. Tang, Y. Xie, J. Zhu, L. Zhang, Z. Liu, Y. Shi, and M. Goodfellow. 2010. *Deinococcus wulumuqiensis* sp. nov., and *Deinococcus xibeiensis* sp. nov., isolated from radiation-polluted soil. Int. J. Syst. Evol. Microbiol. **60:**2006-2010.

Wang, Z. and G. Rossman. 1994. Isolation of DNA fragments from agarose gel by centrifugation. Nucleic Acids Res. **22:**2862 -2863.

Weisburg, W. G., S. J. Giovannoni, and C. R. Woese. 1989. The *Deinococcus-Thermus* phylum and the effect of rRNA composition on phylogenetic tree construction. Syst. Appl. Microbiol. **11:**128-134.

Weon, H.-Y., B.-Y. Kim, P. Schumann, J.-A. Son, J. Jang, S.-J. Go, and S.-W. Kwon. 2007. *Deinococcus cellulosilyticus* sp. nov., isolated from air. Int. J. Syst.

Evol. Microbiol. **57:**1685-1688.

Whitby, M. C., L. Ryder, and R. G. Lloyd. 1993. Reverse branch migration of Holliday junctions by RecG protein: a new mechanism for resolution of intermediates in recombination and DNA repair. Cell **75:**341–350.

White, C., and G. M. Gadd. 1998. Accumulation and effects of cadmium on sulphate-reducing bacterial biofilms. Microbiol. **144:**1407-1415.

White, O., J. A. Eisen, J. F. Heidelberg, E. K. Hickey, J. D. Peterson, R. J. Dodson, D. H. Haft, M. L. Gwinn, W. C. Nelson, D. L. Richardson, K. S. Moffat, H. Qin, L. Jiang, W. Pamphile, M. Crosby, M. Shen, J. J. Vamathevan, P. Lam, L. McDonald, T. Utterback, C. Zalewski, K. S. Makarova, L. Aravind, M. J. Daly, K. W. Minton, R. D. Fleischmann, K. A. Ketchum, K. E. Nelson, S. Salzberg, H. O. Smith, J. Craig, Venter, and C. M. Fraser. 1999. Genome sequence of the radioresistant bacterium *Deinococcus radiodurans* R1. Science **286:**1571-1577.

Whittaker, M. M., V. V. Barynin, S. V. Antonyuk, and J. W. Whittaker. 1999. The oxidized (3,3) state of manganese catalase. Comparison of enzymes from *Thermus thermophilus* and *Lactobacillus plantarum*. Biochemistry **38:**9126-9136.

Wise, M. G., J. V. McArthur, and L. J. Shimkets. 1996. 16S rRNA gene probes for *Deinococcus* species. Syst. Appl. Microbiol. **19:**365-369.

Wong Villarreal, A., and J. S. Caballero Mellado. 2010. Rapid identification of nitrogen-fixing and legume-nodulating *Burkholderia* species based on PCR 16S rRNA species-specific oligonucleotides. Syst. Appl. Microbiol. 33:35-43.

Xu, G., L. Wang, H. Chen, H. Lu, N. Ying, B. Tian, and Y. Hua. 2008. RecO is essential for DNA damage repair in Deinococcus radiodurans. J. Bacteriol. **190:**2624-2628.

Xu, Z., and S. Y. Lee. 1999. Display of Poly histidine peptides on the *Escherichia coli* cell surface by using outer membrane protein C as an anchoring motif. Appl. Environ. Microbiol. **65:** 5142-5147.

Yang, J.-H., H. X. Liu, G. M. Zhu, Y. L. Pan, L. P. Xu, and J. H. Guo. 2008. Diversity analysis of antagonists from rice-associated bacteria and their application in biocontrol of rice diseases. J. Appl. Microbiol. **104:**91-104

Yang, Y., T. Itoh, S.-i. Yokobori, H. Shimada, S. Itahashi, K. Satoh, H. Ohba, I. Narumi, and A. Yamagishi. 2010. *Deinococcus aetherius* sp. nov., isolated from the stratosphere. Int. J. Syst. Evol. Microbiol. **60:**776-779.

Yang, Y., T. Itoh, S.-i. Yokobori, S. Itahashi, H. Shimada, K. Satoh, H. Ohba, I. Narumi, and A. Yamagishi. 2009. *Deinococcus aerius* sp. nov., isolated from the high atmosphere. Int. J. Syst. Evol. Microbiol. **59:**1862-1866.

Yocum, C. F., and V. L. Pecoraro. 1999. Recent advances in the understanding of the biological chemistry of manganese. Curr. Opin. Chem. Biol. **3:**182-187.

Yoo, S.-H., H.-Y. Weon, S.-J. Kim, Y.-S. Kim, B.-Y. Kim, and S. W. Kwon. 2009. *Deinococcus aerolatus* sp. nov. and *Deinococcus aerophilus* sp. nov., isolated from air samples. Int. J. Syst. Evol. Microbiol. **60:**1191-1195.

Yuan Bing Cheng Yuan a, Z.-Z., Li ., Hua Liu , Meng Gao , Yan-Yu Zhang. 2007. Microbial biomass and activity in salt affected soils under arid conditions. Appl. Soil Ecol. **35:**319-328.

Yuan, M., W. Zhang, S. Dai, J. Wu, Y. Wang, T. Tao, M. Chen, and M. Lin. 2009. *Deinococcus gobiensis* sp. nov., an extremely radiation-resistant bacterium. Int. J. Syst. Evol. Microbiol. **59:**1513-1517.

Yun, E. J., and Y. N. Lee. 2000. Production of two different catalase peroxidases by *Deinococcus radiophilus*. FEMS Microbiol. Lett. **184:**155-159.

Zahradka, K., D. Slade, A. Bailone, S. Sommer, D. Averbeck, M. Petranovic, A. B. Lindner, and M. Radman. 2006. Reassembly of shattered chromosomes in *Deinococcus radiodurans*. Nature **443:**569-573.

Zhang, Y. M., J. K. Liu, and T. Y. Wong. 2003. The DNA excision repair system of the highly radioresistant bacterium *Deinococcus radiodurans* is facilitated by the pentose phosphate pathway. Mol. Microbiol. **48:**1317-1323.

Zhang, Y. M., J. K. Liu, M. Shouri, and T. Y. Wong. 2006. Characterization of a Mn dependent Fructose -1, 6-bisphosphate aldolase in *Deinococcus radiodurans*. BioMetals **19:**31-37.

Zhang, Y. M., T. Y. Wong, L. Y. Chen, C. S. Lin, and J. K. Liu. 2000. Induction of a futile Embden-Meyerhof-Parnas pathway in *Deinococcus radiodurans* by Mn: possible role of the pentose phosphate pathway in cell survival. Appl. Environ. Microbiol. **66:**105-112.

Zhang, Y. Q., C. H. Sun, W. J. Li, L. Y. Yu, J. Q. Zhou, Y. Q. Zhang, L. H. Xu, and C. L. Jiang. 2007. *Deinococcus yunweiensis* sp. nov., a gamma- and UV-radiation-resistant bacterium from China. Int. J. Syst. Evol. Microbiol. **57:**370-375.

Zhou, Q., X. Zhang, H. Xu, B. Xu, and Y. Hua. 2006. RadA: a protein involved in DNA damage repair processes of *Deinococcus radiodurans* R1.Chin. Sci. Bull. **51:**2993–2999.