

COBALT, ANTIMONY COMPOUNDS, AND WEAPONS-GRADE TUNGSTEN ALLOY

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Table S4.7 Genetic and related effects of cobalt in acellular systems

Test system	End-point	Result ^a	Concentration (LEC or HIC)	Comments	Reference
<i>Cobalt metal</i>					
Purified DNA from 3T3 mouse cells	DNA strand breaks, alkaline elution	+	1 µg/mL (d ₅₀ , 4 µm)	Isolated DNA was exposed to the cobalt powder.	Anard et al. (1997)
Supercoiled bacteriophage plasmid DNA	DNA damage, depletion of supercoiled DNA	+	10 µg	Nanosized cobalt particles (mean diameter, 20 nm).	Zhang et al. (1998)
<i>Soluble cobalt(II) salts</i>					
<i>Cobalt(II) chloride (CoCl₂)</i>					
Reduction of fidelity of DNA replication	Substitution of Mg ²⁺ in <i>Escherichia coli</i> DNA polymerase, sea urchin nuclear DNA polymerase, and avian myeloblastosis virus DNA polymerase	+	1 mM [130 µg/mL]		Sirover & Loeb (1976)
Calf thymus DNA	Displacement of acridine orange from DNA	+	0.33 mM [43 µg/mL]	Effect was weaker than e.g. with FeSO ₄ or CuCl ₂ .	Richardson et al. (1981)
Human c-Ha-RAS-1 protooncogene	DNA cleavage	(+)	20 µM	Only in the presence of H ₂ O ₂ .	Yamamoto et al. (1989)
Human c-Ha-RAS-1 protooncogene	DNA cleavage	- (+)	20 µM 50 µM	Only in the presence of H ₂ O ₂ .	Kawanishi et al. (1989a, b)
<i>Cobalt(II) sulfate (CoSO₄)</i>					
Isolated human chromatin from myelogenous leukaemia cell line K562	Chemical changes in DNA bases	-	25 µM [4 µg/mL]		Nackerdien et al. (1991)
Isolated human chromatin from myelogenous leukaemia cell line K562	Chemical changes in DNA bases	(+)	25 µM [4 µg/mL]	In the presence of H ₂ O ₂ .	Nackerdien et al. (1991)
Calf thymus DNA	Chemical changes in DNA bases	(+)	25 µM [4 µg/mL]	Tested only in the presence of H ₂ O ₂ .	Nackerdien et al. (1991)
pET28a(+) plasmid DNA	Conformation change in DNA and DNA replication	+	1 mM		Kumar et al. (2017)
Degradation of deoxyribose	Oxidative DNA damage	-	100 µM	Without H ₂ O ₂ .	Moorhouse et al. (1985)
Degradation of deoxyribose	Oxidative DNA damage	(+)	0.025 mM	Concentration of CoSO ₄ 0.01–0.2 mM. In the presence of H ₂ O ₂ .	Moorhouse et al. (1985)

d₅₀, median diameter; HIC, highest ineffective concentration; LEC, lowest effective concentration.

^a +, positive; -, negative; (+), positive in a study of limited quality.

References

- Abdel-Daim MM, Khalil SR, Awad A, Abu Zeid EH, El-Aziz RA, El-Serehy HA (2020). Ethanolic extract of *Moringa oleifera* leaves influences NF- κ B signaling pathway to restore kidney tissue from cobalt-mediated oxidative injury and inflammation in rats. *Nutrients*. 12(4):1031. doi:[10.3390/nu12041031](https://doi.org/10.3390/nu12041031) PMID:[32283757](https://pubmed.ncbi.nlm.nih.gov/32283757/)
- Abdel-Rahman Mohamed A, Metwally MMM, Khalil SR, Salem GA, Ali HA (2019). *Moringa oleifera* extract attenuates the CoCl₂ induced hypoxia of rat's brain: expression pattern of HIF-1 α , NF- κ B, MAO and EPO. *Biomed Pharmacother*. 109:1688–97. doi:[10.1016/j.biopha.2018.11.019](https://doi.org/10.1016/j.biopha.2018.11.019) PMID:[30551423](https://pubmed.ncbi.nlm.nih.gov/30551423/)
- Ajibade TO, Oyagbemi AA, Omobowale TO, Asenuga ER, Adigun KO (2017). Quercetin and vitamin C mitigate cobalt chloride-induced hypertension through reduction in oxidative stress and nuclear factor kappa beta (NF-Kb) expression in experimental rat model. *Biol Trace Elem Res*. 175(2):347–59. doi:[10.1007/s12011-016-0773-5](https://doi.org/10.1007/s12011-016-0773-5) PMID:[27283837](https://pubmed.ncbi.nlm.nih.gov/27283837/)
- Akinrinde AS, Adebisi OE (2019). Neuroprotection by luteolin and gallic acid against cobalt chloride-induced behavioural, morphological and neurochemical alterations in Wistar rats. *Neurotoxicology*. 74:252–63. doi:[10.1016/j.neuro.2019.07.005](https://doi.org/10.1016/j.neuro.2019.07.005) PMID:[31362009](https://pubmed.ncbi.nlm.nih.gov/31362009/)
- Akinrinde AS, Oyagbemi AA, Omobowale TO, Asenuga ER, Ajibade TO (2016). Alterations in blood pressure, antioxidant status and caspase 8 expression in cobalt chloride-induced cardio-renal dysfunction are reversed by *Ocimum gratissimum* and gallic acid in Wistar rats. *J Trace Elem Med Biol*. 36:27–37. doi:[10.1016/j.jtemb.2016.03.015](https://doi.org/10.1016/j.jtemb.2016.03.015) PMID:[27259349](https://pubmed.ncbi.nlm.nih.gov/27259349/)
- Alinovi R, Goldoni M, Pinelli S, Campanini M, Aliati I, Bersani D, et al. (2015). Oxidative and pro-inflammatory effects of cobalt and titanium oxide nanoparticles on aortic and venous endothelial cells. *Toxicol In Vitro*. 29(3):426–37. doi:[10.1016/j.tiv.2014.12.007](https://doi.org/10.1016/j.tiv.2014.12.007) PMID:[25526690](https://pubmed.ncbi.nlm.nih.gov/25526690/)
- Alzhrani RM, Alhadidi Q, Bachu RD, Shah Z, Dey S, Boddu SHS (2017). Tanshinone IIA inhibits VEGF secretion and HIF-1 α expression in cultured human retinal pigment epithelial cells under hypoxia. *Curr Eye Res*. 42(12):1667–73. doi:[10.1080/02713683.2017.1355467](https://doi.org/10.1080/02713683.2017.1355467) PMID:[28937825](https://pubmed.ncbi.nlm.nih.gov/28937825/)
- Anard D, Kirsch-Volders M, Elhajouji A, Belpaeme K, Lison D (1997). In vitro genotoxic effects of hard metal particles assessed by alkaline single cell gel and elution assays. *Carcinogenesis*. 18(1):177–84. doi:[10.1093/carcin/18.1.177](https://doi.org/10.1093/carcin/18.1.177) PMID:[9054604](https://pubmed.ncbi.nlm.nih.gov/9054604/)
- Anjum SA, Lawrence H, Holland JP, Kirby JA, Deehan DJ, Tyson-Capper AJ (2016). Effect of cobalt-mediated toll-like receptor 4 activation on inflammatory responses in endothelial cells. *Oncotarget*. 7(47):76471–8. doi:[10.18632/oncotarget.13260](https://doi.org/10.18632/oncotarget.13260) PMID:[27835611](https://pubmed.ncbi.nlm.nih.gov/27835611/)
- Arlauskas A, Baker RSU, Bonin AM, Tandon RK, Crisp PT, Ellis J (1985). Mutagenicity of metal ions in bacteria. *Environ Res*. 36(2):379–88. doi:[10.1016/0013-9351\(85\)90032-5](https://doi.org/10.1016/0013-9351(85)90032-5) PMID:[3884331](https://pubmed.ncbi.nlm.nih.gov/3884331/)
- Awoyemi OV, Okotie UJ, Oyagbemi AA, Omobowale TO, Asenuga ER, Ola-Davies OE, et al. (2017). Cobalt chloride exposure dose-dependently induced hepatotoxicity through enhancement of cyclooxygenase-2 (COX-2)/B-cell associated protein X (BAX) signaling and genotoxicity in Wistar rats. *Environ Toxicol*. 32(7):1899–907. doi:[10.1002/tox.22412](https://doi.org/10.1002/tox.22412) PMID:[28303633](https://pubmed.ncbi.nlm.nih.gov/28303633/)
- Bae S, Jeong HJ, Cha HJ, Kim K, Choi YM, An IS, et al. (2012). The hypoxia-mimetic agent cobalt chloride induces cell cycle arrest and alters gene expression in U266 multiple myeloma cells. *Int J Mol Med*. 30(5):1180–6. doi:[10.3892/ijmm.2012.1115](https://doi.org/10.3892/ijmm.2012.1115) PMID:[22941251](https://pubmed.ncbi.nlm.nih.gov/22941251/)
- Balaiya S, Murthy RK, Chalam KV (2013). Resveratrol inhibits proliferation of hypoxic choroidal vascular endothelial cells. *Mol Vis*. 19:2385–92. PMID:[24319332](https://pubmed.ncbi.nlm.nih.gov/24319332/)
- Barrak NH, Khajah MA, Luqmani YA (2020). Hypoxic environment may enhance migration/penetration of endocrine resistant MCF7- derived breast cancer cells through monolayers of other non-invasive cancer cells in vitro. *Sci Rep*. 10(1):1127. doi:[10.1038/s41598-020-58055-x](https://doi.org/10.1038/s41598-020-58055-x) PMID:[31980706](https://pubmed.ncbi.nlm.nih.gov/31980706/)
- Bauer I, Wanner GA, Rensing H, Alte C, Miescher EA, Wolf B, et al. (1998). Expression pattern of heme oxygenase isoenzymes 1 and 2 in normal and stress-exposed rat liver. *Hepatology*. 27(3):829–38. doi:[10.1002/hep.510270327](https://doi.org/10.1002/hep.510270327) PMID:[9500714](https://pubmed.ncbi.nlm.nih.gov/9500714/)
- Bi S, Liu JR, Li Y, Wang Q, Liu HK, Yan YG, et al. (2010). γ -Tocotrienol modulates the paracrine secretion of VEGF induced by cobalt(II) chloride via ERK signaling pathway in gastric adenocarcinoma SGC-7901 cell line. *Toxicology*. 274(1–3):27–33. doi:[10.1016/j.tox.2010.05.002](https://doi.org/10.1016/j.tox.2010.05.002) PMID:[20452389](https://pubmed.ncbi.nlm.nih.gov/20452389/)
- Busch W, Kühnel D, Schirmer K, Scholz S (2010). Tungsten carbide cobalt nanoparticles exert hypoxia-like effects on the gene expression level in human keratinocytes. *BMC Genomics*. 11(1):65. doi:[10.1186/1471-2164-11-65](https://doi.org/10.1186/1471-2164-11-65) PMID:[20105288](https://pubmed.ncbi.nlm.nih.gov/20105288/)
- Caicedo MS, Pennekamp PH, McAllister K, Jacobs JJ, Hallab NJ (2010). Soluble ions more than particulate cobalt-alloy implant debris induce monocyte costimulatory molecule expression and release of proinflammatory cytokines critical to metal-induced lymphocyte reactivity. *J Biomed Mater Res A*. 93(4):1312–21. PMID:[19844976](https://pubmed.ncbi.nlm.nih.gov/19844976/)
- Cavallo D, Ciervo A, Fresegna AM, Maiello R, Tassone P, Buresti G, et al. (2015). Investigation on cobalt-oxide nanoparticles cyto-genotoxicity and inflammatory response in two types of respiratory cells. *J Appl Toxicol*. 35(10):1102–13. doi:[10.1002/jat.3133](https://doi.org/10.1002/jat.3133) PMID:[25772588](https://pubmed.ncbi.nlm.nih.gov/25772588/)
- Chang YC, Lin CW, Hsieh MC, Wu HJ, Wu WS, Wu WC, et al. (2017). High mobility group B1 up-regulates angiogenic and fibrogenic factors in human retinal pigment

- epithelial ARPE-19 cells. *Cell Signal*. 40:248–57. doi:[10.1016/j.cellsig.2017.09.019](https://doi.org/10.1016/j.cellsig.2017.09.019) PMID:[28970183](https://pubmed.ncbi.nlm.nih.gov/28970183/)
- Chen CL, Chu JS, Su WC, Huang SC, Lee WY (2010a). Hypoxia and metabolic phenotypes during breast carcinogenesis: expression of HIF-1 α , GLUT1, and CAIX. *Virchows Arch*. 457(1):53–61. doi:[10.1007/s00428-010-0938-0](https://doi.org/10.1007/s00428-010-0938-0) PMID:[20526721](https://pubmed.ncbi.nlm.nih.gov/20526721/)
- Chen DW, Wang H, Bao YF, Xie K (2018a). Notch signaling molecule is involved in the invasion of MiaPaCa2 cells induced by CoCl₂ via regulating epithelial-mesenchymal transition. *Mol Med Rep*. 17(4):4965–72. doi:[10.3892/mmr.2018.8502](https://doi.org/10.3892/mmr.2018.8502) PMID:[29393429](https://pubmed.ncbi.nlm.nih.gov/29393429/)
- Chen F, Chen R, Liu H, Sun R, Huang J, Huang Z, et al. (2017a). BMP-7 ameliorates cobalt alloy particle-induced inflammation by suppressing Th17 responses. *APMIS*. 125(10):880–7. doi:[10.1111/apm.12730](https://doi.org/10.1111/apm.12730) PMID:[28736908](https://pubmed.ncbi.nlm.nih.gov/28736908/)
- Chen J, Han TL, Zhou X, Baker P, Shao Y, Zhang H (2020). Metabolic disparities of different oxidative stress-inducing conditions in HTR8/SVneo cells. *Mol Med Rep*. 21(2):540–8. doi:[10.3892/mmr.2019.10861](https://doi.org/10.3892/mmr.2019.10861) PMID:[31974599](https://pubmed.ncbi.nlm.nih.gov/31974599/)
- Chen LJ, Ito S, Kai H, Nagamine K, Nagai N, Nishizawa M, et al. (2017b). Microfluidic co-cultures of retinal pigment epithelial cells and vascular endothelial cells to investigate choroidal angiogenesis. *Sci Rep*. 7(1):3538. doi:[10.1038/s41598-017-03788-5](https://doi.org/10.1038/s41598-017-03788-5) PMID:[28615726](https://pubmed.ncbi.nlm.nih.gov/28615726/)
- Cheng Y, Chen G, Hong L, Zhou L, Hu M, Li B, et al. (2013). How does hypoxia inducible factor-1 α participate in enhancing the glycolysis activity in cervical cancer? *Ann Diagn Pathol*. 17(3):305–11. doi:[10.1016/j.anndiagpath.2012.12.002](https://doi.org/10.1016/j.anndiagpath.2012.12.002) PMID:[23375385](https://pubmed.ncbi.nlm.nih.gov/23375385/)
- Christova T, Duridanova D, Braykova A, Setchenska M, Bolton T (2001). Heme oxygenase is the main protective enzyme in rat liver upon 6-day administration of cobalt chloride. *Arch Toxicol*. 75(8):445–51. doi:[10.1007/s002040100253](https://doi.org/10.1007/s002040100253) PMID:[11757667](https://pubmed.ncbi.nlm.nih.gov/11757667/)
- Christova TY, Duridanova DB, Setchenska MS (2002). Enhanced heme oxygenase activity increases the antioxidant defense capacity of guinea pig liver upon acute cobalt chloride loading: comparison with rat liver. *Comp Biochem Physiol C Toxicol Pharmacol*. 131(2):177–84. doi:[10.1016/S1532-0456\(01\)00287-3](https://doi.org/10.1016/S1532-0456(01)00287-3) PMID:[11879785](https://pubmed.ncbi.nlm.nih.gov/11879785/)
- Christova TY, Gorneva GA, Taxirov SI, Duridanova DB, Setchenska MS (2003). Effect of cisplatin and cobalt chloride on antioxidant enzymes in the livers of Lewis lung carcinoma-bearing mice: protective role of heme oxygenase. *Toxicol Lett*. 138(3):235–42. doi:[10.1016/S0378-4274\(02\)00416-2](https://doi.org/10.1016/S0378-4274(02)00416-2) PMID:[12565200](https://pubmed.ncbi.nlm.nih.gov/12565200/)
- Ciğerci İH, Ali MM, Kaygısız ŞY, Liman R (2016). Genotoxicity assessment of cobalt chloride in *Eisenia hortensis* earthworms coelomocytes by comet assay and micronucleus test. *Chemosphere*. 144:754–7. doi:[10.1016/j.chemosphere.2015.09.053](https://doi.org/10.1016/j.chemosphere.2015.09.053) PMID:[26408983](https://pubmed.ncbi.nlm.nih.gov/26408983/)
- Clyne N, Hofman-Bang C, Haga Y, Hatori N, Marklund SL, Pehrsson SK, et al. (2001). Chronic cobalt exposure affects antioxidants and ATP production in rat myocardium. *Scand J Clin Lab Invest*. 61(8):609–14. doi:[10.1080/003655101753267964](https://doi.org/10.1080/003655101753267964) PMID:[11768320](https://pubmed.ncbi.nlm.nih.gov/11768320/)
- Dai M, Cui P, Yu M, Han J, Li H, Xiu R (2008). Melatonin modulates the expression of VEGF and HIF-1 α induced by CoCl₂ in cultured cancer cells. *J Pineal Res*. 44(2):121–6. doi:[10.1111/j.1600-079X.2007.00498.x](https://doi.org/10.1111/j.1600-079X.2007.00498.x) PMID:[18289162](https://pubmed.ncbi.nlm.nih.gov/18289162/)
- Daído A, Aniya Y (1994). Alteration of liver glutathione S-transferase and protease activities by cobalt chloride treatment of rats. *Jpn J Pharmacol*. 66(3):357–62. doi:[10.1254/jjp.66.357](https://doi.org/10.1254/jjp.66.357) PMID:[7532736](https://pubmed.ncbi.nlm.nih.gov/7532736/)
- Demir E, Kocaoğlu S, Cetin H, Kaya B (2009). Antigenotoxic effects of *Citrus aurantium* L. fruit peel oil on mutagenicity of two alkylating agents and two metals in the *Drosophila* wing spot test. *Environ Mol Mutagen*. 50(6):483–8. doi:[10.1002/em.20484](https://doi.org/10.1002/em.20484) PMID:[19350605](https://pubmed.ncbi.nlm.nih.gov/19350605/)
- Devitt BM, Queally JM, Vioreanu M, Butler JS, Murray D, Doran PP, et al. (2010). Cobalt ions induce chemokine secretion in a variety of systemic cell lines. *Acta Orthop*. 81(6):756–64. doi:[10.3109/17453674.2010.537806](https://doi.org/10.3109/17453674.2010.537806) PMID:[21110705](https://pubmed.ncbi.nlm.nih.gov/21110705/)
- Dick CA, Brown DM, Donaldson K, Stone V (2003). The role of free radicals in the toxic and inflammatory effects of four different ultrafine particle types. *Inhal Toxicol*. 15(1):39–52. doi:[10.1080/08958370304454](https://doi.org/10.1080/08958370304454) PMID:[12476359](https://pubmed.ncbi.nlm.nih.gov/12476359/)
- Díez-Tercero L, Delgado LM, Bosch-Rué E, Perez RA (2021). Evaluation of the immunomodulatory effects of cobalt, copper and magnesium ions in a pro inflammatory environment. *Sci Rep*. 11(1):11707. doi:[10.1038/s41598-021-91070-0](https://doi.org/10.1038/s41598-021-91070-0) PMID:[34083604](https://pubmed.ncbi.nlm.nih.gov/34083604/)
- Egilsson V, Evans IH, Wilkie D (1979). Toxic and mutagenic effects of carcinogens on the mitochondria of *Saccharomyces cerevisiae*. *Mol Gen Genet*. 174(1):39–46. doi:[10.1007/BF00433303](https://doi.org/10.1007/BF00433303) PMID:[384160](https://pubmed.ncbi.nlm.nih.gov/384160/)
- Eltit F, Noble J, Sharma M, Benam N, Haegert A, Bell RH, et al. (2021). Cobalt ions induce metabolic stress in synovial fibroblasts and secretion of cytokines/chemokines that may be diagnostic markers for adverse local tissue reactions to hip implants. *Acta Biomater*. 131:581–94. doi:[10.1016/j.actbio.2021.06.039](https://doi.org/10.1016/j.actbio.2021.06.039) PMID:[34192572](https://pubmed.ncbi.nlm.nih.gov/34192572/)
- Ertuğrul H, Yalçın B, Güneş M, Kaya B (2020). Ameliorative effects of melatonin against nano and ionic cobalt induced genotoxicity in two in vivo *Drosophila* assays. *Drug Chem Toxicol*. 43(3):279–86. doi:[10.1080/01480545.2019.1585444](https://doi.org/10.1080/01480545.2019.1585444) PMID:[30880493](https://pubmed.ncbi.nlm.nih.gov/30880493/)
- Erturk FA, Ay H, Nardemir G, Agar G (2013). Molecular determination of genotoxic effects of cobalt and nickel on maize (*Zea mays* L.) by RAPD and protein analyses. *Toxicol Ind Health*. 29(7):662–71. doi:[10.1177/0748233712442709](https://doi.org/10.1177/0748233712442709) PMID:[22499271](https://pubmed.ncbi.nlm.nih.gov/22499271/)

- Faisal M, Saquib Q, Alatar AA, Al-Khedhairy AA, Ahmed M, Ansari SM, et al. (2016). Cobalt oxide nanoparticles aggravate DNA damage and cell death in eggplant via mitochondrial swelling and NO signalling pathway. *Biol Res.* 49(1):20. doi:[10.1186/s40659-016-0080-9](https://doi.org/10.1186/s40659-016-0080-9) PMID:[26988690](https://pubmed.ncbi.nlm.nih.gov/26988690/)
- Feng S, Zhang Z, Mo Y, Tong R, Zhong Z, Chen Z, et al. (2020). Activation of NLRP3 inflammasome in hepatocytes after exposure to cobalt nanoparticles: the role of oxidative stress. *Toxicol In Vitro.* 69:104967. doi:[10.1016/j.tiv.2020.104967](https://doi.org/10.1016/j.tiv.2020.104967) PMID:[32805375](https://pubmed.ncbi.nlm.nih.gov/32805375/)
- Frings VG, Müller D, Storz G, Rossi A, Sennefelder H, Adam C, et al. (2019). Improved metal allergen reactivity of artificial skin models by integration of Toll-like receptor 4-positive cells. *Contact Dermatitis.* 81(4):254–61. [Erratum in: *Contact Dermatitis.* 2020;82(2):136.] doi:[10.1111/cod.13336](https://doi.org/10.1111/cod.13336) PMID:[31198997](https://pubmed.ncbi.nlm.nih.gov/31198997/)
- Fukunaga M, Kurachi Y, Mizuguchi Y (1982). Action of some metal ions on yeast chromosomes. *Chem Pharm Bull (Tokyo).* 30(8):3017–9. doi:[10.1248/cpb.30.3017](https://doi.org/10.1248/cpb.30.3017) PMID:[6754115](https://pubmed.ncbi.nlm.nih.gov/6754115/)
- Garoui E, Ben Amara I, Driss D, Elwej A, Chaabouni SE, Boudawara T, et al. (2013). Effects of cobalt on membrane ATPases, oxidant, and antioxidant values in the cerebrum and cerebellum of suckling rats. *Biol Trace Elem Res.* 154(3):387–95. doi:[10.1007/s12011-013-9746-0](https://doi.org/10.1007/s12011-013-9746-0) PMID:[23857379](https://pubmed.ncbi.nlm.nih.gov/23857379/)
- Garoui EM, Fetoui H, Ayadi Makni F, Boudawara T, Zeghal N (2011). Cobalt chloride induces hepatotoxicity in adult rats and their suckling pups. *Exp Toxicol Pathol.* 63(1–2):9–15. doi:[10.1016/j.etp.2009.09.003](https://doi.org/10.1016/j.etp.2009.09.003) PMID:[19819122](https://pubmed.ncbi.nlm.nih.gov/19819122/)
- Gibbs S, Kosten I, Veldhuizen R, Spiekstra S, Corsini E, Roggen E, et al. (2018). Assessment of metal sensitizer potency with the reconstructed human epidermis IL-18 assay. *Toxicology.* 393:62–72. doi:[10.1016/j.tox.2017.10.014](https://doi.org/10.1016/j.tox.2017.10.014) PMID:[29079364](https://pubmed.ncbi.nlm.nih.gov/29079364/)
- Goebeler M, Meinardus-Hager G, Roth J, Goerdts S, Sorg C (1993). Nickel chloride and cobalt chloride, two common contact sensitizers, directly induce expression of intercellular adhesion molecule-1 (ICAM-1), vascular cell adhesion molecule-1 (VCAM-1), and endothelial leukocyte adhesion molecule (ELAM-1) by endothelial cells. *J Invest Dermatol.* 100(6):759–65. doi:[10.1111/1523-1747.ep12476328](https://doi.org/10.1111/1523-1747.ep12476328) PMID:[7684425](https://pubmed.ncbi.nlm.nih.gov/7684425/)
- Gonzales S, Polizio AH, Erario MA, Tomaro ML (2005). Glutamine is highly effective in preventing in vivo cobalt-induced oxidative stress in rat liver. *World J Gastroenterol.* 11(23):3533–8. doi:[10.3748/wjg.v11.i23.3533](https://doi.org/10.3748/wjg.v11.i23.3533) PMID:[15962369](https://pubmed.ncbi.nlm.nih.gov/15962369/)
- Gori C, Zucconi L (1957). Cytological activity induced by a group of inorganic compounds in *Allium cepa*. *Caryologia.* 10:29–45. [Italian] doi:[10.1080/00087114.1957.10797611](https://doi.org/10.1080/00087114.1957.10797611)
- Gray MJ, Zhang J, Ellis LM, Semenza GL, Evans DB, Watowich SS, et al. (2005). HIF-1 α , STAT3, CBP/p300 and Ref-1/APE are components of a transcriptional complex that regulates Src-dependent hypoxia-induced expression of VEGF in pancreatic and prostate carcinomas. *Oncogene.* 24(19):3110–20. doi:[10.1038/sj.onc.1208513](https://doi.org/10.1038/sj.onc.1208513) PMID:[15735682](https://pubmed.ncbi.nlm.nih.gov/15735682/)
- Gu Y, Liu W, Liu G, Li X, Lu P (2021). Assessing the protective effects of cryptotanshinone on CoCl₂-induced hypoxia in RPE cells. *Mol Med Rep.* 24(4):739. doi:[10.3892/mmr.2021.12379](https://doi.org/10.3892/mmr.2021.12379) PMID:[34435647](https://pubmed.ncbi.nlm.nih.gov/34435647/)
- Guan D, Su Y, Li Y, Wu C, Meng Y, Peng X, et al. (2015). Tetramethylpyrazine inhibits CoCl₂-induced neurotoxicity through enhancement of Nrf2/GCLC/GSH and suppression of HIF1 α /NOX2/ROS pathways. *J Neurochem.* 134(3):551–65. doi:[10.1111/jnc.13161](https://doi.org/10.1111/jnc.13161) PMID:[25952107](https://pubmed.ncbi.nlm.nih.gov/25952107/)
- Guildford AL, Poletti T, Osbourne LH, Di Cerbo A, Gatti AM, Santin M (2009). Nanoparticles of a different source induce different patterns of activation in key biochemical and cellular components of the host response. *J R Soc Interface.* 6(41):1213–21. doi:[10.1098/rsif.2009.0021](https://doi.org/10.1098/rsif.2009.0021) PMID:[19324665](https://pubmed.ncbi.nlm.nih.gov/19324665/)
- Han YH, Xia L, Song LP, Zheng Y, Chen WL, Zhang L, et al. (2006). Comparative proteomic analysis of hypoxia-treated and untreated human leukemic U937 cells. *Proteomics.* 6(11):3262–74. doi:[10.1002/pmic.200500754](https://doi.org/10.1002/pmic.200500754) PMID:[16622835](https://pubmed.ncbi.nlm.nih.gov/16622835/)
- Hatori N, Pehrsson SK, Clyne N, Hansson G, Hofman-Bang C, Marklund SL, et al. (1993). Acute cobalt exposure and oxygen radical scavengers in the rat myocardium. *Biochim Biophys Acta.* 1181(3):257–60. doi:[10.1016/0925-4439\(93\)90029-Z](https://doi.org/10.1016/0925-4439(93)90029-Z) PMID:[8391326](https://pubmed.ncbi.nlm.nih.gov/8391326/)
- Inoue T, Ohta Y, Sadaie Y, Kada T (1981). Effect of cobaltous chloride on spontaneous mutation induction in a *Bacillus subtilis* mutator strain. *Mutat Res.* 91(1):41–5. doi:[10.1016/0165-7992\(81\)90068-3](https://doi.org/10.1016/0165-7992(81)90068-3) PMID:[6782475](https://pubmed.ncbi.nlm.nih.gov/6782475/)
- Johansson A, Lundborg M, Wiernik A, Jarstrand C, Camner P (1986). Rabbit alveolar macrophages after long-term inhalation of soluble cobalt. *Environ Res.* 41(2):488–96. doi:[10.1016/S0013-9351\(86\)80143-8](https://doi.org/10.1016/S0013-9351(86)80143-8) PMID:[3780647](https://pubmed.ncbi.nlm.nih.gov/3780647/)
- Kada T, Kanematsu N (1978). Reduction of N-methyl-N'-nitro-N-nitrosoguanidine-induced mutations by cobalt chloride in *Escherichia coli*. *Proc Jpn Acad, Ser B, Phys Biol Sci.* 54 5:234–7. doi:[10.2183/pjab.54.234](https://doi.org/10.2183/pjab.54.234)
- Kalefetoğlu Macar T, Macar O, Yalçın E, Çavuşoğlu K (2021). Protective roles of grape seed (*Vitis vinifera* L.) extract against cobalt(II) nitrate stress in *Allium cepa* L. root tip cells. *Environ Sci Pollut Res Int.* 28(1):270–9. doi:[10.1007/s11356-020-10532-6](https://doi.org/10.1007/s11356-020-10532-6) PMID:[32809124](https://pubmed.ncbi.nlm.nih.gov/32809124/)
- Kaliman PA, Nikitchenko IV, Sokol OA, Strel'chenko EV (2001). Regulation of heme oxygenase activity in rat liver during oxidative stress induced by cobalt chloride and mercury chloride. *Biochemistry (Mosc).* 66(1):77–82. doi:[10.1023/A:1002889814723](https://doi.org/10.1023/A:1002889814723) PMID:[11240397](https://pubmed.ncbi.nlm.nih.gov/11240397/)

- Kalinich JF, Vergara VB, Hoffman JF (2022). Serum indicators of oxidative damage from embedded metal fragments in a rat model. *Oxid Med Cell Longev*. 2022:5394303. doi:[10.1155/2022/5394303](https://doi.org/10.1155/2022/5394303) PMID:[35154566](https://pubmed.ncbi.nlm.nih.gov/35154566/)
- Kalpna S, Dhananjay S, Anju B, Lilly G, Sai Ram M (2008). Cobalt chloride attenuates hypobaric hypoxia induced vascular leakage in rat brain: molecular mechanisms of action of cobalt chloride. *Toxicol Appl Pharmacol*. 231(3):354–63. doi:[10.1016/j.taap.2008.05.008](https://doi.org/10.1016/j.taap.2008.05.008) PMID:[18635243](https://pubmed.ncbi.nlm.nih.gov/18635243/)
- Kanematsu N, Hara M, Kada T (1980). Rec assay and mutagenicity studies on metal compounds. *Mutat Res*. 77(2):109–16. doi:[10.1016/0165-1218\(80\)90127-5](https://doi.org/10.1016/0165-1218(80)90127-5) PMID:[6769036](https://pubmed.ncbi.nlm.nih.gov/6769036/)
- Kappas A, Drummond GS, Sardana MK (1985). Sn-protoporphyrin rapidly and markedly enhances the heme saturation of hepatic tryptophan pyrrolase. Evidence that this synthetic metalloporphyrin increases the functional content of heme in the liver. *J Clin Invest*. 75(1):302–5. doi:[10.1172/JCI11689](https://doi.org/10.1172/JCI11689) PMID:[3965510](https://pubmed.ncbi.nlm.nih.gov/3965510/)
- Karri V, Lidén C, Fyhrquist N, Högberg J, Karlsson HL (2021). Impact of mono-culture vs. co-culture of keratinocytes and monocytes on cytokine responses induced by important skin sensitizers. *J Immunotoxicol*. 18(1):74–84. doi:[10.1080/1547691X.2021.1905754](https://doi.org/10.1080/1547691X.2021.1905754) PMID:[34019775](https://pubmed.ncbi.nlm.nih.gov/34019775/)
- Kasprzak KS, Zastawny TH, North SL, Riggs CW, Diwan BA, Rice JM, et al. (1994). Oxidative DNA base damage in renal, hepatic, and pulmonary chromatin of rats after intraperitoneal injection of cobalt(II) acetate. *Chem Res Toxicol*. 7(3):329–35. doi:[10.1021/tx00039a009](https://doi.org/10.1021/tx00039a009) PMID:[8075364](https://pubmed.ncbi.nlm.nih.gov/8075364/)
- Kawanishi S, Inoue S, Yamamoto K (1989b). Hydroxyl radical and singlet oxygen production and DNA damage induced by carcinogenic metal compounds and hydrogen peroxide. *Biol Trace Elem Res*. 21(1):367–72. doi:[10.1007/BF02917277](https://doi.org/10.1007/BF02917277) PMID:[2484615](https://pubmed.ncbi.nlm.nih.gov/2484615/)
- Kawanishi S, Yamamoto K, Inoue S (1989a). Site-specific DNA damage induced by sulfite in the presence of cobalt(II) ion. Role of sulfate radical. *Biochem Pharmacol*. 38(20):3491–6. doi:[10.1016/0006-2952\(89\)90119-6](https://doi.org/10.1016/0006-2952(89)90119-6) PMID:[2818640](https://pubmed.ncbi.nlm.nih.gov/2818640/)
- Kaya B, Creus A, Velázquez A, Yanikoğlu A, Marcos R (2002). Genotoxicity is modulated by ascorbic acid. Studies using the wing spot test in *Drosophila*. *Mutat Res*. 520(1–2):93–101. doi:[10.1016/S1383-5718\(02\)00173-0](https://doi.org/10.1016/S1383-5718(02)00173-0) PMID:[12297148](https://pubmed.ncbi.nlm.nih.gov/12297148/)
- Kewitz S, Kurch L, Volkmer I, Staeger MS (2016). Stimulation of the hypoxia pathway modulates chemotherapy resistance in Hodgkin's lymphoma cells. *Tumour Biol*. 37(6):8229–37. doi:[10.1007/s13277-015-4705-3](https://doi.org/10.1007/s13277-015-4705-3) PMID:[26718211](https://pubmed.ncbi.nlm.nih.gov/26718211/)
- Khalil SR, El Bohi KM, Khater S, Abd El-fattah AH, Mahmoud FA, Farag MR (2020). *Moringa oleifera* leaves ethanolic extract influences DNA damage signalling pathways to protect liver tissue from cobalt -triggered apoptosis in rats. *Ecotoxicol Environ Saf*. 200:110716. doi:[10.1016/j.ecoenv.2020.110716](https://doi.org/10.1016/j.ecoenv.2020.110716) PMID:[32450433](https://pubmed.ncbi.nlm.nih.gov/32450433/)
- Kharab P, Singh I (1985). Genotoxic effects of potassium dichromate, sodium arsenite, cobalt chloride and lead nitrate in diploid yeast. *Mutat Res*. 155(3):117–20. doi:[10.1016/0165-1218\(85\)90128-4](https://doi.org/10.1016/0165-1218(85)90128-4) PMID:[3883155](https://pubmed.ncbi.nlm.nih.gov/3883155/)
- Kharab P, Singh I (1987). Induction of respiratory deficiency in yeast by salts of chromium, arsenic, cobalt and lead. *Indian J Exp Biol*. 25(2):141–2. PMID:[3311978](https://pubmed.ncbi.nlm.nih.gov/3311978/)
- Kim HH, Lee SE, Chung WJ, Choi Y, Kwack K, Kim SW, et al. (2002). Stabilization of hypoxia-inducible factor-1 α is involved in the hypoxic stimuli-induced expression of vascular endothelial growth factor in osteoblastic cells. *Cytokine*. 17(1):14–27. doi:[10.1006/cyto.2001.0985](https://doi.org/10.1006/cyto.2001.0985) PMID:[11886167](https://pubmed.ncbi.nlm.nih.gov/11886167/)
- Kim KS, Rajagopal V, Gonsalves C, Johnson C, Kalra VK (2006b). A novel role of hypoxia-inducible factor in cobalt chloride- and hypoxia-mediated expression of IL-8 chemokine in human endothelial cells. *J Immunol*. 177(10):7211–24. doi:[10.4049/jimmunol.177.10.7211](https://doi.org/10.4049/jimmunol.177.10.7211) PMID:[17082639](https://pubmed.ncbi.nlm.nih.gov/17082639/)
- Kirkland D, Brock T, Haddouk H, Hargeaves V, Lloyd M, Mc Garry S, et al. (2015). New investigations into the genotoxicity of cobalt compounds and their impact on overall assessment of genotoxic risk. *Regul Toxicol Pharmacol*. 73(1):311–38. doi:[10.1016/j.yrtph.2015.07.016](https://doi.org/10.1016/j.yrtph.2015.07.016) PMID:[26210821](https://pubmed.ncbi.nlm.nih.gov/26210821/)
- Klasson M, Lindberg M, Särndahl E, Westberg H, Bryngelsson IL, Tuerxun K, et al. (2021a). Dose- and time-dependent changes in viability and IL-6, CXCL8 and CCL2 production by HaCaT-cells exposed to cobalt. Effects of high and low calcium growth conditions. *PLoS One*. 16(6):e0252159. doi:[10.1371/journal.pone.0252159](https://doi.org/10.1371/journal.pone.0252159) PMID:[34086734](https://pubmed.ncbi.nlm.nih.gov/34086734/)
- Klasson M, Lindberg M, Westberg H, Bryngelsson IL, Tuerxun K, Persson A, et al. (2021b). Dermal exposure to cobalt studied *in vitro* in keratinocytes - effects of cobalt exposure on inflammasome activated cytokines, and mRNA response. *Biomarkers*. 26(8):674–84. doi:[10.1080/1354750X.2021.1975823](https://doi.org/10.1080/1354750X.2021.1975823) PMID:[34496682](https://pubmed.ncbi.nlm.nih.gov/34496682/)
- Knyazev E, Maltseva D, Raygorodskaya M, Shkurnikov M (2021). HIF-dependent *NFATC1* activation upregulates *ITGA5* and *PLAUR* in intestinal epithelium in inflammatory bowel disease. *Front Genet*. 12:791640. doi:[10.3389/fgene.2021.791640](https://doi.org/10.3389/fgene.2021.791640) PMID:[34858489](https://pubmed.ncbi.nlm.nih.gov/34858489/)
- Kong IC, Ko KS, Koh DC, Chon CM (2020). Comparative effects of particle sizes of cobalt nanoparticles to nine biological activities. *Int J Mol Sci*. 21(18):6767. doi:[10.3390/ijms21186767](https://doi.org/10.3390/ijms21186767) PMID:[32942696](https://pubmed.ncbi.nlm.nih.gov/32942696/)
- Kumar V, Mishra RK, Kaur G, Dutta D (2017). Cobalt and nickel impair DNA metabolism by the oxidative stress independent pathway. *Metallomics*. 9(11):1596–609. doi:[10.1039/C7MT00231A](https://doi.org/10.1039/C7MT00231A) PMID:[29058747](https://pubmed.ncbi.nlm.nih.gov/29058747/)

- Kuno Y, Tochihara N, Koike S (1980). The effects of cobalt chloride on the formation of blood lipid peroxide related to glutathione peroxidase in the erythrocytes of rabbits. *Jpn J Hyg.* 35(4):665–9. doi:[10.1265/jjh.35.665](https://doi.org/10.1265/jjh.35.665) PMID:[7241837](https://pubmed.ncbi.nlm.nih.gov/7241837/)
- Laumonier T, Ruffieux E, Paccaud J, Kindler V, Hannouche D (2020). In vitro evaluation of human myoblast function after exposure to cobalt and chromium ions. *J Orthop Res.* 38(6):1398–406. doi:[10.1002/jor.24579](https://doi.org/10.1002/jor.24579) PMID:[31883135](https://pubmed.ncbi.nlm.nih.gov/31883135/)
- Law PC, Auyeung KK, Chan LY, Ko JK (2012). Astragalus saponins downregulate vascular endothelial growth factor under cobalt chloride-stimulated hypoxia in colon cancer cells. *BMC Complement Altern Med.* 12(1):160. doi:[10.1186/1472-6882-12-160](https://doi.org/10.1186/1472-6882-12-160) PMID:[22992293](https://pubmed.ncbi.nlm.nih.gov/22992293/)
- Lawrence H, Deehan D, Holland J, Kirby J, Tyson-Capper A (2014). The immunobiology of cobalt. Demonstration of a potential aetiology for inflammatory pseudotumours after metal-on-metal replacement of the hip. *Bone Joint J.* 96-B(9):1172–7. doi:[10.1302/0301-620X.96B9.33476](https://doi.org/10.1302/0301-620X.96B9.33476) PMID:[25183586](https://pubmed.ncbi.nlm.nih.gov/25183586/)
- Lawrence H, Mawdesley AE, Holland JP, Kirby JA, Deehan DJ, Tyson-Capper AJ (2016). Targeting Toll-like receptor 4 prevents cobalt-mediated inflammation. *Oncotarget.* 7(7):7578–85. doi:[10.18632/oncotarget.7105](https://doi.org/10.18632/oncotarget.7105) PMID:[26840091](https://pubmed.ncbi.nlm.nih.gov/26840091/)
- Lee M, Hwang JT, Yun H, Kim EJ, Kim MJ, Kim SS, et al. (2006). Critical roles of AMP-activated protein kinase in the carcinogenic metal-induced expression of VEGF and HIF-1 proteins in DU145 prostate carcinoma. *Biochem Pharmacol.* 72(1):91–103. doi:[10.1016/j.bcp.2006.03.021](https://doi.org/10.1016/j.bcp.2006.03.021) PMID:[16678800](https://pubmed.ncbi.nlm.nih.gov/16678800/)
- Lee SG, Lee H, Rho HM (2001). Transcriptional repression of the human *p53* gene by cobalt chloride mimicking hypoxia. *FEBS Lett.* 507(3):259–63. doi:[10.1016/S0014-5793\(01\)02989-1](https://doi.org/10.1016/S0014-5793(01)02989-1) PMID:[11696352](https://pubmed.ncbi.nlm.nih.gov/11696352/)
- Lewis CPL, Demedts M, Nemery B (1991). Indices of oxidative stress in hamster lung following exposure to cobalt(II) ions: in vivo and in vitro studies. *Am J Respir Cell Mol Biol.* 5(2):163–9. doi:[10.1165/ajrcmb/5.2.163](https://doi.org/10.1165/ajrcmb/5.2.163) PMID:[1892647](https://pubmed.ncbi.nlm.nih.gov/1892647/)
- Li X, Liu X, Xing Y, Zeng L, Liu X, Shen H, et al. (2022). Erianin controls collagen-mediated retinal angiogenesis via the RhoA/ROCK1 signaling pathway induced by the alpha2/beta1 integrin-collagen interaction. *Invest Ophthalmol Vis Sci.* 63(1):27. doi:[10.1167/iovs.63.1.27](https://doi.org/10.1167/iovs.63.1.27) PMID:[35060996](https://pubmed.ncbi.nlm.nih.gov/35060996/)
- Li Y, Liu G, Cai D, Pan B, Lin Y, Li X, et al. (2014). H₂S inhibition of chemical hypoxia-induced proliferation of HPASMCs is mediated by the upregulation of COX-2/PGL₂. *Int J Mol Med.* 33(2):359–66. doi:[10.3892/ijmm.2013.1579](https://doi.org/10.3892/ijmm.2013.1579) PMID:[24337227](https://pubmed.ncbi.nlm.nih.gov/24337227/)
- Lindegren CC, Nagai S, Nagai H (1958). Induction of respiratory deficiency in yeast by manganese, copper, cobalt and nickel. *Nature.* 182(4633):446–8. doi:[10.1038/182446a0](https://doi.org/10.1038/182446a0) PMID:[13577873](https://pubmed.ncbi.nlm.nih.gov/13577873/)
- Liu HC, Chang WHS, Lin FH, Lu KH, Tsuang YH, Sun JS (1999). Cytokine and prostaglandin E₂ release from leukocytes in response to metal ions derived from different prosthetic materials: an in vitro study. *Artif Organs.* 23(12):1099–106. doi:[10.1111/j.1525-1594.1999.06343.x](https://doi.org/10.1111/j.1525-1594.1999.06343.x) PMID:[10619928](https://pubmed.ncbi.nlm.nih.gov/10619928/)
- Llesuy SF, Tomaro ML (1994). Heme oxygenase and oxidative stress. Evidence of involvement of bilirubin as physiological protector against oxidative damage. *Biochim Biophys Acta.* 1223(1):9–14. doi:[10.1016/0167-4889\(94\)90067-1](https://doi.org/10.1016/0167-4889(94)90067-1) PMID:[8061058](https://pubmed.ncbi.nlm.nih.gov/8061058/)
- Loboda A, Jazwa A, Wegiel B, Jozkowicz A, Dulak J (2005). Heme oxygenase-1-dependent and -independent regulation of angiogenic genes expression: effect of cobalt protoporphyrin and cobalt chloride on VEGF and IL-8 synthesis in human microvascular endothelial cells. *Cell Mol Biol (Noisy-le-grand).* 51(4):347–55. PMID:[16309584](https://pubmed.ncbi.nlm.nih.gov/16309584/)
- Luo L, Petit A, Antoniou J, Zukor DJ, Huk OL, Liu RC, et al. (2005). Effect of cobalt and chromium ions on MMP-1, TIMP-1, and TNF- α gene expression in human U937 macrophages: a role for tyrosine kinases. *Biomaterials.* 26(28):5587–93. doi:[10.1016/j.biomaterials.2005.02.013](https://doi.org/10.1016/j.biomaterials.2005.02.013) PMID:[15878362](https://pubmed.ncbi.nlm.nih.gov/15878362/)
- Ma R, Gu Y, Groome LJ, Wang Y (2011). ADAM17 regulates TNF α production by placental trophoblasts. *Placenta.* 32(12):975–80. doi:[10.1016/j.placenta.2011.09.015](https://doi.org/10.1016/j.placenta.2011.09.015) PMID:[22018416](https://pubmed.ncbi.nlm.nih.gov/22018416/)
- Macar O, Kalefetoğlu Macar T, Çavuşoğlu K, Yalçın E (2020). Determination of protective effect of carob (*Ceratonia siliqua* L.) extract against cobalt(II) nitrate-induced toxicity. *Environ Sci Pollut Res Int.* 27(32):40253–61. doi:[10.1007/s11356-020-10009-6](https://doi.org/10.1007/s11356-020-10009-6) PMID:[32661972](https://pubmed.ncbi.nlm.nih.gov/32661972/)
- Maeda T, Shibai A, Yokoi N, Tarusawa Y, Kawada M, Kotani H, et al. (2021). Mutational property of newly identified mutagen L-glutamic acid γ -hydrazide in *Escherichia coli*. *Mutat Res.* 823:111759. doi:[10.1016/j.mrfmmm.2021.111759](https://doi.org/10.1016/j.mrfmmm.2021.111759) PMID:[34304126](https://pubmed.ncbi.nlm.nih.gov/34304126/)
- Mahkamova K, Latar N, Aspinall S, Meeson A (2018). Hypoxia increases thyroid cancer stem cell-enriched side population. *World J Surg.* 42(2):350–7. doi:[10.1007/s00268-017-4331-x](https://doi.org/10.1007/s00268-017-4331-x) PMID:[29167950](https://pubmed.ncbi.nlm.nih.gov/29167950/)
- Maines MD, Kappas A (1974). Cobalt induction of hepatic heme oxygenase; with evidence that cytochrome P-450 is not essential for this enzyme activity. *Proc Natl Acad Sci USA.* 71(11):4293–7. doi:[10.1073/pnas.71.11.4293](https://doi.org/10.1073/pnas.71.11.4293) PMID:[4530983](https://pubmed.ncbi.nlm.nih.gov/4530983/)
- Malard V, Berenguer F, Prat O, Ruat S, Steinmetz G, Quemeneur E (2007). Global gene expression profiling in human lung cells exposed to cobalt. *BMC Genomics.* 8(1):147. doi:[10.1186/1471-2164-8-147](https://doi.org/10.1186/1471-2164-8-147) PMID:[17553155](https://pubmed.ncbi.nlm.nih.gov/17553155/)
- Malard V, Chardan L, Roussi S, Darolles C, Sage N, Gaillard JC, et al. (2012). Analytical constraints for the analysis of human cell line secretomes by shotgun

- proteomics. *J Proteomics*. 75(3):1043–54. doi:[10.1016/j.jprot.2011.10.025](https://doi.org/10.1016/j.jprot.2011.10.025) PMID:[22079246](https://pubmed.ncbi.nlm.nih.gov/22079246/)
- Mao ZJ, Tang QJ, Zhang CA, Qin ZF, Pang B, Wei PK, et al. (2012). Anti-proliferation and anti-invasion effects of diosgenin on gastric cancer BGC-823 cells with HIF-1 α shRNAs. *Int J Mol Sci*. 13(5):6521–33. doi:[10.3390/ijms13056521](https://doi.org/10.3390/ijms13056521) PMID:[22754381](https://pubmed.ncbi.nlm.nih.gov/22754381/)
- Maurage CA, Adam E, Minéo JF, Sarrazin S, Debunne M, Siminski RM, et al. (2009). Endocan expression and localization in human glioblastomas. *J Neuropathol Exp Neurol*. 68(6):633–41. doi:[10.1097/NEN.0b013e3181a52a7f](https://doi.org/10.1097/NEN.0b013e3181a52a7f) PMID:[19458546](https://pubmed.ncbi.nlm.nih.gov/19458546/)
- Milosevic J, Adler I, Manaenko A, Schwarz SC, Walkinshaw G, Arend M, et al. (2009). Non-hypoxic stabilization of hypoxia-inducible factor alpha (HIF- α): relevance in neural progenitor/stem cells. *Neurotox Res*. 15(4):367–80. doi:[10.1007/s12640-009-9043-z](https://doi.org/10.1007/s12640-009-9043-z) PMID:[19384570](https://pubmed.ncbi.nlm.nih.gov/19384570/)
- Minchenko A, Salceda S, Bauer T, Caro J (1994b). Hypoxia regulatory elements of the human vascular endothelial growth factor gene. *Cell Mol Biol Res*. 40(1):35–9. PMID:[7528597](https://pubmed.ncbi.nlm.nih.gov/7528597/)
- Mochizuki H, Kada T (1982). Antimutagenic action of cobaltous chloride on Trp-P-1-induced mutations in *Salmonella typhimurium* TA98 and TA1538. *Mutat Res*. 95(2–3):145–57. doi:[10.1016/0027-5107\(82\)90253-6](https://doi.org/10.1016/0027-5107(82)90253-6) PMID:[6750380](https://pubmed.ncbi.nlm.nih.gov/6750380/)
- Molitoris KH, Kazi AA, Koos RD (2009). Inhibition of oxygen-induced hypoxia-inducible factor-1 α degradation unmasks estradiol induction of vascular endothelial growth factor expression in ECC-1 cancer cells in vitro. *Endocrinology*. 150(12):5405–14. doi:[10.1210/en.2009-0884](https://doi.org/10.1210/en.2009-0884) PMID:[19819950](https://pubmed.ncbi.nlm.nih.gov/19819950/)
- Moorhouse CP, Halliwell B, Grootveld M, Gutteridge JMC (1985). Cobalt(II) ion as a promoter of hydroxyl radical and possible ‘crypto-hydroxyl’ radical formation under physiological conditions. Differential effects of hydroxyl radical scavengers. *Biochim Biophys Acta*. 843(3):261–8. doi:[10.1016/0304-4165\(85\)90147-3](https://doi.org/10.1016/0304-4165(85)90147-3) PMID:[2998477](https://pubmed.ncbi.nlm.nih.gov/2998477/)
- Morita H, Kuno Y, Koike S (1982). The effects of cobalt on superoxide dismutase activity, methemoglobin formation and lipid peroxide in rabbit erythrocytes. *Jpn J Hyg*. 37(3):597–600. doi:[10.1265/jjh.37.597](https://doi.org/10.1265/jjh.37.597) PMID:[7176165](https://pubmed.ncbi.nlm.nih.gov/7176165/)
- Nackerdien Z, Kasprzak KS, Rao G, Halliwell B, Dizdaroglu M (1991). Nickel(II)- and cobalt(II)-dependent damage by hydrogen peroxide to the DNA bases in isolated human chromatin. *Cancer Res*. 51(21):5837–42. PMID:[1933852](https://pubmed.ncbi.nlm.nih.gov/1933852/)
- Nersisyan S, Galatenko A, Chekova M, Tonevitsky A (2021). Hypoxia-induced miR-148a downregulation contributes to poor survival in colorectal cancer. *Front Genet*. 12:662468. doi:[10.3389/fgene.2021.662468](https://doi.org/10.3389/fgene.2021.662468) PMID:[34135940](https://pubmed.ncbi.nlm.nih.gov/34135940/)
- Ninomiya JT, Kuzma SA, Schnettler TJ, Krolikowski JG, Struve JA, Weihrauch D (2013). Metal ions activate vascular endothelial cells and increase lymphocyte chemotaxis and binding. *J Orthop Res*. 31(9):1484–91. doi:[10.3390/nu12041031](https://doi.org/10.3390/nu12041031) PMID:[32283757](https://pubmed.ncbi.nlm.nih.gov/32283757/)
- Nishihashi K, Kawashima K, Nomura T, Urakami-Takebayashi Y, Miyazaki M, Takano M, et al. (2017). Cobalt chloride induces expression and function of breast cancer resistance protein (BCRP/ABCG2) in human renal proximal tubular epithelial cell line HK-2. *Biol Pharm Bull*. 40(1):82–7. doi:[10.1248/bpb.b16-00684](https://doi.org/10.1248/bpb.b16-00684) PMID:[28049953](https://pubmed.ncbi.nlm.nih.gov/28049953/)
- Nishioka H (1975). Mutagenic activities of metal compounds in bacteria. *Mutat Res*. 31(3):185–9. doi:[10.1016/0165-1161\(75\)90088-6](https://doi.org/10.1016/0165-1161(75)90088-6) PMID:[805366](https://pubmed.ncbi.nlm.nih.gov/805366/)
- Nordquist L, Friederich-Persson M, Fasching A, Liss P, Shoji K, Nangaku M, et al. (2015). Activation of hypoxia-inducible factors prevents diabetic nephropathy. *J Am Soc Nephrol*. 26(2):328–38. doi:[10.1681/ASN.2013090990](https://doi.org/10.1681/ASN.2013090990) PMID:[25183809](https://pubmed.ncbi.nlm.nih.gov/25183809/)
- Nordström G, Säljö A, Li SJ, Hasselgren PO (1990). Effects of ischemia and reperfusion on protein synthesis in livers with different glutathione levels. *Ann Surg*. 211(1):97–102. doi:[10.1097/0000658-199001000-00017](https://doi.org/10.1097/0000658-199001000-00017) PMID:[2294851](https://pubmed.ncbi.nlm.nih.gov/2294851/)
- NTP (2014). NTP technical report on the toxicology studies of cobalt metal (CASRN 7440-48-4) in F344/N rats and B6C3F1/N mice and toxicology and carcinogenesis studies of cobalt metal in F344/NTac rats and B6C3F1/N mice (inhalation studies), Technical Report 581. Research Triangle Park (NC), USA: National Toxicology Program. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK567171/>, accessed 19 April 2022.
- Numazawa S, Oguro T, Yoshida T, Kuroiwa Y (1989a). Synergistic induction of rat hepatic ornithine decarboxylase by multiple doses of cobalt chloride. *Chem Biol Interact*. 72(3):157–67. doi:[10.1016/0009-2797\(89\)90002-1](https://doi.org/10.1016/0009-2797(89)90002-1) PMID:[2605669](https://pubmed.ncbi.nlm.nih.gov/2605669/)
- Nunes SC, Lopes-Coelho F, Gouveia-Fernandes S, Ramos C, Pereira SA, Serpa J (2018). Cysteine boosts the evolutionary adaptation to CoCl₂ mimicked hypoxia conditions, favouring carboplatin resistance in ovarian cancer. *BMC Evol Biol*. 18(1):97. doi:[10.1186/s12862-018-1214-1](https://doi.org/10.1186/s12862-018-1214-1) PMID:[29921232](https://pubmed.ncbi.nlm.nih.gov/29921232/)
- Nyga A, Hart A, Tetley TD (2015). Importance of the HIF pathway in cobalt nanoparticle-induced cytotoxicity and inflammation in human macrophages. *Nanotoxicology*. 9(7):905–17. doi:[10.3109/17435390.2014.991430](https://doi.org/10.3109/17435390.2014.991430) PMID:[25676618](https://pubmed.ncbi.nlm.nih.gov/25676618/)
- Ogawa HI, Ohyama Y, Ohsumi Y, Kakimoto K, Kato Y, Shirai Y, et al. (1999). Cobaltous chloride-induced mutagenesis in the *supF* tRNA gene of *Escherichia coli*. *Mutagenesis*. 14(2):249–53. doi:[10.1093/mutage/14.2.249](https://doi.org/10.1093/mutage/14.2.249) PMID:[10229930](https://pubmed.ncbi.nlm.nih.gov/10229930/)

- Ogawa HI, Sakata K, Inouye T, Jyosui S, Niyitani Y, Kakimoto K, et al. (1986). Combined mutagenicity of cobalt(II) salt and heteroaromatic compounds in *Salmonella typhimurium*. *Mutat Res Genet Toxicol Test.* 172(2):97–104. doi:[10.1016/0165-1218\(86\)90068-6](https://doi.org/10.1016/0165-1218(86)90068-6) PMID:[3531840](https://pubmed.ncbi.nlm.nih.gov/3531840/)
- Ogawa HI, Shibahara T, Iwata H, Okada T, Tsuruta S, Kakimoto K, et al. (1994). Genotoxic activities in vivo of cobaltous chloride and other metal chlorides as assayed in the *Drosophila* wing spot test. *Mutat Res.* 320(1–2):133–40. doi:[10.1016/0165-1218\(94\)90065-5](https://doi.org/10.1016/0165-1218(94)90065-5) PMID:[7506380](https://pubmed.ncbi.nlm.nih.gov/7506380/)
- Oh JH, Oh J, Togloom A, Kim SW, Huh K (2013). Effects of *Ginkgo biloba* extract on cultured human retinal pigment epithelial cells under chemical hypoxia. *Curr Eye Res.* 38(10):1072–82. doi:[10.3109/02713683.2013.804093](https://doi.org/10.3109/02713683.2013.804093) PMID:[23790153](https://pubmed.ncbi.nlm.nih.gov/23790153/)
- Osera C, Martindale JL, Amadio M, Kim J, Yang X, Moad CA, et al. (2015). Induction of VEGFA mRNA translation by CoCl₂ mediated by HuR. *RNA Biol.* 12(10):1121–30. doi:[10.1080/15476286.2015.1085276](https://doi.org/10.1080/15476286.2015.1085276) PMID:[26325091](https://pubmed.ncbi.nlm.nih.gov/26325091/)
- Oyagbemi AA, Akinrinde AS, Adebisi OE, Jarikre TA, Omobowale TO, Ola-Davies OE, et al. (2020). Luteolin supplementation ameliorates cobalt-induced oxidative stress and inflammation by suppressing NF-κB/Kim-1 signaling in the heart and kidney of rats. *Environ Toxicol Pharmacol.* 80:103488. doi:[10.1016/j.etap.2020.103488](https://doi.org/10.1016/j.etap.2020.103488) PMID:[32898663](https://pubmed.ncbi.nlm.nih.gov/32898663/)
- Oyagbemi AA, Omobowale TO, Awoyomi OV, Ajibade TO, Falayi OO, Ogunpolu BS, et al. (2019). Cobalt chloride toxicity elicited hypertension and cardiac complication via induction of oxidative stress and upregulation of COX-2/Bax signaling pathway. *Hum Exp Toxicol.* 38(5):519–32. doi:[10.1177/0960327118812158](https://doi.org/10.1177/0960327118812158) PMID:[30596275](https://pubmed.ncbi.nlm.nih.gov/30596275/)
- Pagano DA, Zeiger E (1992). Conditions for detecting the mutagenicity of divalent metals in *Salmonella typhimurium*. *Environ Mol Mutagen.* 19(2):139–46. doi:[10.1002/em.2850190208](https://doi.org/10.1002/em.2850190208) PMID:[1541255](https://pubmed.ncbi.nlm.nih.gov/1541255/)
- Park H, Lee DS, Yim MJ, Choi YH, Park S, Seo SK, et al. (2015). 3,3'-Diindolylmethane inhibits VEGF expression through the HIF-1α and NF-κB pathways in human retinal pigment epithelial cells under chemical hypoxic conditions. *Int J Mol Med.* 36(1):301–8. doi:[10.3892/ijmm.2015.2202](https://doi.org/10.3892/ijmm.2015.2202) PMID:[25955241](https://pubmed.ncbi.nlm.nih.gov/25955241/)
- Peters K, Unger RE, Gatti AM, Sabbioni E, Tsaryk R, Kirkpatrick CJ (2007). Metallic nanoparticles exhibit paradoxical effects on oxidative stress and pro-inflammatory response in endothelial cells in vitro. *Int J Immunopathol Pharmacol.* 20(4):685–95. doi:[10.1177/039463200702000404](https://doi.org/10.1177/039463200702000404) PMID:[18179741](https://pubmed.ncbi.nlm.nih.gov/18179741/)
- Petrarca C, Perrone A, Verna N, Verginelli F, Ponti J, Sabbioni E, et al. (2006). Cobalt nano-particles modulate cytokine in vitro release by human mononuclear cells mimicking autoimmune disease. *Int J Immunopathol Pharmacol.* 19(4 Suppl):11–4. PMID:[17291400](https://pubmed.ncbi.nlm.nih.gov/17291400/)
- Prazmo W, Balbin E, Baranowska H, Ejchart A, Putrament A (1975). Manganese mutagenesis in yeast. II. Conditions of induction and characteristics of mitochondrial respiratory deficient *Saccharomyces cerevisiae* mutants induced with manganese and cobalt. *Genet Res.* 26(1):21–9. doi:[10.1017/S0016672300015810](https://doi.org/10.1017/S0016672300015810) PMID:[767216](https://pubmed.ncbi.nlm.nih.gov/767216/)
- Putrament A, Baranowska H, Ejchart A, Jachymczyk W (1977). Manganese mutagenesis in yeast. VI. Mn²⁺ uptake, mitDNA replication and E^R induction. Comparison with other divalent cations. *Mol Gen Genet.* 151(1):69–76. doi:[10.1007/BF00446914](https://doi.org/10.1007/BF00446914) PMID:[325369](https://pubmed.ncbi.nlm.nih.gov/325369/)
- Queally JM, Devitt BM, Butler JS, Malizia AP, Murray D, Doran PP, et al. (2009). Cobalt ions induce chemokine secretion in primary human osteoblasts. *J Orthop Res.* 27(7):855–64. doi:[10.1002/jor.20837](https://doi.org/10.1002/jor.20837) PMID:[19132727](https://pubmed.ncbi.nlm.nih.gov/19132727/)
- Rachmawati D, Bontkes HJ, Verstege MI, Muris J, von Blomberg BME, Scheper RJ, et al. (2013). Transition metal sensing by Toll-like receptor-4: next to nickel, cobalt and palladium are potent human dendritic cell stimulators. *Contact Dermat.* 68(6):331–8. doi:[10.1111/cod.12042](https://doi.org/10.1111/cod.12042) PMID:[23692033](https://pubmed.ncbi.nlm.nih.gov/23692033/)
- Reinardy HC, Syrett JR, Jeffree RA, Henry TB, Jha AN (2013). Cobalt-induced genotoxicity in male zebrafish (*Danio rerio*), with implications for reproduction and expression of DNA repair genes. *Aquat Toxicol.* 126:224–30. doi:[10.1016/j.aquatox.2012.11.007](https://doi.org/10.1016/j.aquatox.2012.11.007) PMID:[23246864](https://pubmed.ncbi.nlm.nih.gov/23246864/)
- Rellinger EJ, Romain C, Choi S, Qiao J, Chung DH (2015). Silencing gastrin-releasing peptide receptor suppresses key regulators of aerobic glycolysis in neuroblastoma cells. *Pediatr Blood Cancer.* 62(4):581–6. doi:[10.1002/pbc.25348](https://doi.org/10.1002/pbc.25348) PMID:[25630799](https://pubmed.ncbi.nlm.nih.gov/25630799/)
- Richardson CL, Verna J, Schulman GE, Shipp K, Grant AD (1981). Metal mutagens and carcinogens effectively displace acridine orange from DNA as measured by fluorescence polarization. *Environ Mutagen.* 3(5):545–53. doi:[10.1002/em.2860030506](https://doi.org/10.1002/em.2860030506) PMID:[6793355](https://pubmed.ncbi.nlm.nih.gov/6793355/)
- Rossmann TG, Molina M, Meyer LW (1984). The genetic toxicology of metal compounds: I. Induction of λ prophage in *E coli* WP2_λ(λ). *Environ Mutagen.* 6(1):59–69. doi:[10.1002/em.2860060108](https://doi.org/10.1002/em.2860060108) PMID:[6229401](https://pubmed.ncbi.nlm.nih.gov/6229401/)
- Safronova O, Nakahama K, Onodera M, Muneta T, Morita I (2003). Effect of hypoxia on monocyte chemotactic protein-1 (MCP-1) gene expression induced by Interleukin-1β in human synovial fibroblasts. [published correction appears in *Inflamm Res.* 53(4):170]. *Inflamm Res.* 52(11):480–6. doi:[10.1007/s00011-003-1205-5](https://doi.org/10.1007/s00011-003-1205-5) PMID:[14652683](https://pubmed.ncbi.nlm.nih.gov/14652683/)
- Sato A, Virgona N, Ando A, Ota M, Yano T (2014). A redox-silent analogue of tocotrienol inhibits cobalt(II) chloride-induced VEGF expression via Yes signaling in mesothelioma cells. *Biol Pharm Bull.* 37(5):865–70. doi:[10.1248/bpb.b13-00846](https://doi.org/10.1248/bpb.b13-00846) PMID:[24790010](https://pubmed.ncbi.nlm.nih.gov/24790010/)

- Saxena S, Shukla D, Saxena S, Khan YA, Singh M, Bansal A, et al. (2010). Hypoxia preconditioning by cobalt chloride enhances endurance performance and protects skeletal muscles from exercise-induced oxidative damage in rats. *Acta Physiol (Oxf)*. 200(3):249–63. doi:[10.1111/j.1748-1716.2010.02136.x](https://doi.org/10.1111/j.1748-1716.2010.02136.x) PMID:[20384596](https://pubmed.ncbi.nlm.nih.gov/20384596/)
- Schmalz G, Schweikl H, Hiller KA (2000). Release of prostaglandin E₂, IL-6 and IL-8 from human oral epithelial culture models after exposure to compounds of dental materials. *Eur J Oral Sci*. 108(5):442–8. doi:[10.1034/j.1600-0722.2000.108005442.x](https://doi.org/10.1034/j.1600-0722.2000.108005442.x) PMID:[11037761](https://pubmed.ncbi.nlm.nih.gov/11037761/)
- Sears JE, Hoppe G (2005). Triamcinolone acetamide destabilizes VEGF mRNA in Müller cells under continuous cobalt stimulation. *Invest Ophthalmol Vis Sci*. 46(11):4336–41. doi:[10.1167/iovs.05-0565](https://doi.org/10.1167/iovs.05-0565) PMID:[16249516](https://pubmed.ncbi.nlm.nih.gov/16249516/)
- Sheffer M, Simon AJ, Jacob-Hirsch J, Rechavi G, Domany E, Givol D, et al. (2011). Genome-wide analysis discloses reversal of the hypoxia-induced changes of gene expression in colon cancer cells by zinc supplementation. *Oncotarget*. 2(12):1191–202. doi:[10.18632/oncotarget.395](https://doi.org/10.18632/oncotarget.395) PMID:[22202117](https://pubmed.ncbi.nlm.nih.gov/22202117/)
- Shrivastava K, Shukla D, Bansal A, Sairam M, Banerjee PK, Ilavazhagan G (2008). Neuroprotective effect of cobalt chloride on hypobaric hypoxia-induced oxidative stress. *Neurochem Int*. 52(3):368–75. doi:[10.1016/j.neuint.2007.07.005](https://doi.org/10.1016/j.neuint.2007.07.005) PMID:[17706837](https://pubmed.ncbi.nlm.nih.gov/17706837/)
- Singh I (1983). Induction of reverse mutation and mitotic gene conversion by some metal compounds in *Saccharomyces cerevisiae*. *Mutat Res*. 117(1–2):149–52. doi:[10.1016/0165-1218\(83\)90162-3](https://doi.org/10.1016/0165-1218(83)90162-3) PMID:[6339905](https://pubmed.ncbi.nlm.nih.gov/6339905/)
- Sirover MA, Loeb LA (1976). Metal activation of DNA synthesis. *Biochem Biophys Res Commun*. 70(3):812–7. doi:[10.1016/0006-291X\(76\)90664-1](https://doi.org/10.1016/0006-291X(76)90664-1) PMID:[779784](https://pubmed.ncbi.nlm.nih.gov/779784/)
- Slomiany MG, Black LA, Kibbey MM, Day TA, Rosenzweig SA (2006). IGF-1 induced vascular endothelial growth factor secretion in head and neck squamous cell carcinoma. *Biochem Biophys Res Commun*. 342(3):851–8. doi:[10.1016/j.bbrc.2006.02.043](https://doi.org/10.1016/j.bbrc.2006.02.043) PMID:[16499871](https://pubmed.ncbi.nlm.nih.gov/16499871/)
- Stelzer KJ, Klaassen CD (1985). Effect of cobalt on biliary excretion of bilirubin and glutathione. *J Toxicol Environ Health*. 15(6):813–22. doi:[10.1080/15287398509530707](https://doi.org/10.1080/15287398509530707) PMID:[3840533](https://pubmed.ncbi.nlm.nih.gov/3840533/)
- Stewart J, Siavash H, Hebert C, Norris K, Nikitakis NG, Sauk JJ (2003). Phenotypic switching of VEGF and collagen XVIII during hypoxia in head and neck squamous carcinoma cells. *Oral Oncol*. 39(8):862–9. doi:[10.1016/S1368-8375\(03\)00110-6](https://doi.org/10.1016/S1368-8375(03)00110-6) PMID:[13679210](https://pubmed.ncbi.nlm.nih.gov/13679210/)
- Sumbayev VV (2001). Activities of apoptotic signal 1-regulating protein kinase and poly-(ADP-ribose) polymerase and internucleosomal DNA fragmentation in rat liver during oxidative stress induced by cobalt chloride. *Bull Exp Biol Med*. 131(2):119–20. doi:[10.1023/A:1017571323899](https://doi.org/10.1023/A:1017571323899) PMID:[11391389](https://pubmed.ncbi.nlm.nih.gov/11391389/)
- Sun Z, Mohamed MAA, Park SY, Yi TH (2015). Fucosterol protects cobalt chloride induced inflammation by the inhibition of hypoxia-inducible factor through PI3K/Akt pathway. *Int Immunopharmacol*. 29(2):642–7. doi:[10.1016/j.intimp.2015.09.016](https://doi.org/10.1016/j.intimp.2015.09.016) PMID:[26395918](https://pubmed.ncbi.nlm.nih.gov/26395918/)
- Ton TVT, Kovi RC, Peddada TN, Chhabria RM, Shockley KR, Flagler ND, et al. (2021). Cobalt-induced oxidative stress contributes to alveolar/bronchiolar carcinogenesis in B6C3F1/N mice. *Arch Toxicol*. 95(10):3171–90. doi:[10.1007/s00204-021-03146-5](https://doi.org/10.1007/s00204-021-03146-5) PMID:[34468815](https://pubmed.ncbi.nlm.nih.gov/34468815/)
- Tso WW, Fung WP (1981). Mutagenicity of metallic cations. *Toxicol Lett*. 8(4–5):195–200. doi:[10.1016/0378-4274\(81\)90100-4](https://doi.org/10.1016/0378-4274(81)90100-4) PMID:[7022752](https://pubmed.ncbi.nlm.nih.gov/7022752/)
- Vales G, Demir E, Kaya B, Creus A, Marcos R (2013). Genotoxicity of cobalt nanoparticles and ions in *Drosophila*. *Nanotoxicology*. 7(4):462–8. doi:[10.3109/17435390.2012.689882](https://doi.org/10.3109/17435390.2012.689882) PMID:[22548285](https://pubmed.ncbi.nlm.nih.gov/22548285/)
- Vengellur A, Phillips JM, Hogenesch JB, LaPres JJ (2005). Gene expression profiling of hypoxia signaling in human hepatocellular carcinoma cells. *Physiol Genomics*. 22(3):308–18. doi:[10.1152/physiolgenomics.00045.2004](https://doi.org/10.1152/physiolgenomics.00045.2004) PMID:[15942021](https://pubmed.ncbi.nlm.nih.gov/15942021/)
- Verstraelen S, Remy S, Casals E, De Boever P, Witters H, Gatti A, et al. (2014). Gene expression profiles reveal distinct immunological responses of cobalt and cerium dioxide nanoparticles in two in vitro lung epithelial cell models. *Toxicol Lett*. 228(3):157–69. doi:[10.1016/j.toxlet.2014.05.006](https://doi.org/10.1016/j.toxlet.2014.05.006) PMID:[24821434](https://pubmed.ncbi.nlm.nih.gov/24821434/)
- Von Rosen G (1964). Mutations induced by the action of metal ions in pism II. Further investigations on the mutagenic action of metal ions and comparison with the activity of ionizing radiation. *Hereditas*. 51(1):89–134. doi:[10.1111/j.1601-5223.1964.tb01923.x](https://doi.org/10.1111/j.1601-5223.1964.tb01923.x)
- Wan R, Mo Y, Zhang Z, Jiang M, Tang S, Zhang Q (2017). Cobalt nanoparticles induce lung injury, DNA damage and mutations in mice. *Part Fibre Toxicol*. 14(1):38. doi:[10.1186/s12989-017-0219-z](https://doi.org/10.1186/s12989-017-0219-z) PMID:[28923112](https://pubmed.ncbi.nlm.nih.gov/28923112/)
- Wang D, Wang L, Gu J, Yang H, Liu N, Lin Y, et al. (2014). Scutellarin inhibits high glucose-induced and hypoxia-mimetic agent-induced angiogenic effects in human retinal endothelial cells through reactive oxygen species/hypoxia-inducible factor-1 α /vascular endothelial growth factor pathway. *J Cardiovasc Pharmacol*. 64(3):218–27. doi:[10.1097/FJC.0000000000000109](https://doi.org/10.1097/FJC.0000000000000109) PMID:[25192544](https://pubmed.ncbi.nlm.nih.gov/25192544/)
- Wang JY, Wicklund BH, Gustilo RB, Tsukayama DT (1996b). Titanium, chromium and cobalt ions modulate the release of bone-associated cytokines by human monocytes/macrophages in vitro. *Biomaterials*. 17(23):2233–40. doi:[10.1016/0142-9612\(96\)00072-5](https://doi.org/10.1016/0142-9612(96)00072-5) PMID:[8968517](https://pubmed.ncbi.nlm.nih.gov/8968517/)
- Wang K, Lei J, Zou J, Xiao H, Chen A, Liu X, et al. (2013a). Mipu1, a novel direct target gene, is involved in hypoxia inducible factor 1-mediated cytoprotection. *PLoS One*. 8(12):e82827. doi:[10.1371/journal.pone.0082827](https://doi.org/10.1371/journal.pone.0082827) PMID:[24349374](https://pubmed.ncbi.nlm.nih.gov/24349374/)

- Wang X, Yokoi I, Liu J, Mori A (1993). Cobalt(II) and nickel(II) ions as promoters of free radicals in vivo: detected directly using electron spin resonance spectrometry in circulating blood in rats. *Arch Biochem Biophys.* 306(2):402–6. doi:[10.1006/abbi.1993.1529](https://doi.org/10.1006/abbi.1993.1529) PMID:[8215442](https://pubmed.ncbi.nlm.nih.gov/8215442/)
- Wang Y, Sang A, Zhu M, Zhang G, Guan H, Ji M, et al. (2016b). Tissue factor induces VEGF expression via activation of the Wnt/ β -catenin signaling pathway in ARPE-19 cells. *Mol Vis.* 22:886–97. PMID:[27499609](https://pubmed.ncbi.nlm.nih.gov/27499609/)
- Wellinghausen N, Driessen C, Rink L (1996). Stimulation of human peripheral blood mononuclear cells by zinc and related cations. *Cytokine.* 8(10):767–71. doi:[10.1006/cyto.1996.0102](https://doi.org/10.1006/cyto.1996.0102) PMID:[8980878](https://pubmed.ncbi.nlm.nih.gov/8980878/)
- Wen Z, Huang C, Xu Y, Xiao Y, Tang L, Dai J, et al. (2016). α -Solanine inhibits vascular endothelial growth factor expression by down-regulating the ERK1/2-HIF-1 α and STAT3 signaling pathways. *Eur J Pharmacol.* 771:93–8. doi:[10.1016/j.ejphar.2015.12.020](https://doi.org/10.1016/j.ejphar.2015.12.020) PMID:[26688571](https://pubmed.ncbi.nlm.nih.gov/26688571/)
- Wong PK (1988). Mutagenicity of heavy metals. *Bull Environ Contam Toxicol.* 40(4):597–603. doi:[10.1007/BF01688386](https://doi.org/10.1007/BF01688386) PMID:[3285919](https://pubmed.ncbi.nlm.nih.gov/3285919/)
- Xia M, Huang R, Sun Y, Semenza GL, Aldred SF, Witt KL, et al. (2009). Identification of chemical compounds that induce HIF-1 α activity. *Toxicol Sci.* 112(1):153–63. doi:[10.1093/toxsci/kfp123](https://doi.org/10.1093/toxsci/kfp123) PMID:[19502547](https://pubmed.ncbi.nlm.nih.gov/19502547/)
- Xu M, Zheng YL, Xie XY, Liang JY, Pan FS, Zheng SG, et al. (2014). Sorafenib blocks the HIF-1 α /VEGFA pathway, inhibits tumor invasion, and induces apoptosis in hepatoma cells. *DNA Cell Biol.* 33(5):275–81. doi:[10.1089/dna.2013.2184](https://doi.org/10.1089/dna.2013.2184) PMID:[24611881](https://pubmed.ncbi.nlm.nih.gov/24611881/)
- Yamamoto A, Kohyama Y, Hanawa T (2002). Mutagenicity evaluation of forty-one metal salts by the *umu* test. *J Biomed Mater Res.* 59(1):176–83. doi:[10.1002/jbm.1231](https://doi.org/10.1002/jbm.1231) PMID:[11745551](https://pubmed.ncbi.nlm.nih.gov/11745551/)
- Yamamoto K, Inoue S, Yamazaki A, Yoshinaga T, Kawanishi S (1989). Site-specific DNA damage induced by cobalt(II) ion and hydrogen peroxide: role of singlet oxygen. *Chem Res Toxicol.* 2(4):234–9. doi:[10.1021/tx00010a004](https://doi.org/10.1021/tx00010a004) PMID:[2562423](https://pubmed.ncbi.nlm.nih.gov/2562423/)
- Yang C, Ling H, Zhang M, Yang Z, Wang X, Zeng F, et al. (2011a). Oxidative stress mediates chemical hypoxia-induced injury and inflammation by activating NF- κ B-COX-2 pathway in HaCaT cells. *Mol Cells.* 31(6):531–8. doi:[10.1007/s10059-011-1025-3](https://doi.org/10.1007/s10059-011-1025-3) PMID:[21533553](https://pubmed.ncbi.nlm.nih.gov/21533553/)
- Yang C, Yang Z, Zhang M, Dong Q, Wang X, Lan A, et al. (2011b). Hydrogen sulfide protects against chemical hypoxia-induced cytotoxicity and inflammation in HaCaT cells through inhibition of ROS/NF- κ B/COX-2 pathway. *PLoS One.* 6(7):e21971. doi:[10.1371/journal.pone.0021971](https://doi.org/10.1371/journal.pone.0021971) PMID:[21779360](https://pubmed.ncbi.nlm.nih.gov/21779360/)
- Yang G, Xu S, Peng L, Li H, Zhao Y, Hu Y (2016). The hypoxia-mimetic agent CoCl₂ induces chemotherapy resistance in LOVO colorectal cancer cells. *Mol Med Rep.* 13(3):2583–9. doi:[10.3892/mmr.2016.4836](https://doi.org/10.3892/mmr.2016.4836) PMID:[26846577](https://pubmed.ncbi.nlm.nih.gov/26846577/)
- Yeşilada E (2001). Genotoxicity testing of some metals in the *Drosophila* wing somatic mutation and recombination test. *Bull Environ Contam Toxicol.* 66(4):464–9. doi:[10.1007/s001280029](https://doi.org/10.1007/s001280029) PMID:[11443308](https://pubmed.ncbi.nlm.nih.gov/11443308/)
- Yıldız M, Çiğerci IH, Konuk M, Fidan AF, Terzi H (2009). Determination of genotoxic effects of copper sulphate and cobalt chloride in *Allium cepa* root cells by chromosome aberration and comet assays. *Chemosphere.* 75(7):934–8. doi:[10.1016/j.chemosphere.2009.01.023](https://doi.org/10.1016/j.chemosphere.2009.01.023) PMID:[19201446](https://pubmed.ncbi.nlm.nih.gov/19201446/)
- Zeiger E, Anderson B, Haworth S, Lawlor T, Mortelmans K (1992). Salmonella mutagenicity tests: V. Results from the testing of 311 chemicals. *Environ Mol Mutagen.* 19(Suppl 21):2–141. doi:[10.1002/em.2850190603](https://doi.org/10.1002/em.2850190603) PMID:[1541260](https://pubmed.ncbi.nlm.nih.gov/1541260/)
- Zhang H, Ji Z, Xia T, Meng H, Low-Kam C, Liu R, et al. (2012). Use of metal oxide nanoparticle band gap to develop a predictive paradigm for oxidative stress and acute pulmonary inflammation. *ACS Nano.* 6(5):4349–68. doi:[10.1021/nn3010087](https://doi.org/10.1021/nn3010087) PMID:[22502734](https://pubmed.ncbi.nlm.nih.gov/22502734/)
- Zhang N, Hong B, Zhou C, Du X, Chen S, Deng X, et al. (2017). Cobalt chloride-induced hypoxia induces epithelial-mesenchymal transition in renal carcinoma cell lines. *Ann Clin Lab Sci.* 47(1):40–6. PMID:[28249915](https://pubmed.ncbi.nlm.nih.gov/28249915/)
- Zhang Q, Kusaka Y, Sato K, Nakakuki K, Kohyama N, Donaldson K (1998). Differences in the extent of inflammation caused by intratracheal exposure to three ultrafine metals: role of free radicals. *J Toxicol Environ Health A.* 53(6):423–38. doi:[10.1080/009841098159169](https://doi.org/10.1080/009841098159169) PMID:[9537280](https://pubmed.ncbi.nlm.nih.gov/9537280/)
- Zhao C, Moreno-Nieves U, Di Battista JA, Fernandes MJ, Touaibia M, Bourgoin SG (2015a). Chemical hypoxia brings to light altered autocrine sphingosine-1-phosphate signalling in rheumatoid arthritis synovial fibroblasts. *Mediators Inflamm.* 2015:436525. doi:[10.1155/2015/436525](https://doi.org/10.1155/2015/436525) PMID:[26556954](https://pubmed.ncbi.nlm.nih.gov/26556954/)
- Zhao J, Geng YU, Hua H, Cun B, Chen Q, Xi X, et al. (2015b). Fenofibrate inhibits the expression of VEGFC and VEGFR-3 in retinal pigmented epithelial cells exposed to hypoxia. *Exp Ther Med.* 10(4):1404–12. doi:[10.3892/etm.2015.2697](https://doi.org/10.3892/etm.2015.2697) PMID:[26622498](https://pubmed.ncbi.nlm.nih.gov/26622498/)
- Zheng F, Jang WC, Fung FK, Lo ACY, Wong IYH (2016). Up-regulation of ENO1 by HIF-1 α in retinal pigment epithelial cells after hypoxic challenge is not involved in the regulation of VEGF secretion. *PLoS One.* 11(2):e0147961. doi:[10.1371/journal.pone.0147961](https://doi.org/10.1371/journal.pone.0147961) PMID:[26882120](https://pubmed.ncbi.nlm.nih.gov/26882120/)
- Zheng F, Luo Z, Zheng C, Li J, Zeng J, Yang H, et al. (2019). Comparison of the neurotoxicity associated with cobalt nanoparticles and cobalt chloride in Wistar rats. *Toxicol Appl Pharmacol.* 369:90–9. doi:[10.1016/j.taap.2019.03.003](https://doi.org/10.1016/j.taap.2019.03.003) PMID:[30849457](https://pubmed.ncbi.nlm.nih.gov/30849457/)