Ergothioneine

From Wikipedia, the free encyclopedia

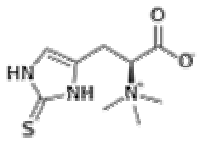
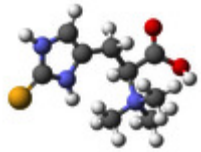
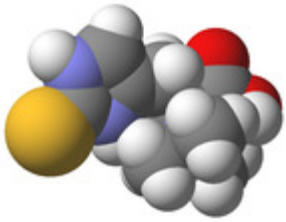
Ergothioneine is a naturally occurring amino acid and is a thiourea derivative of histidine, containing a sulfur atom in the imidazole ring. This compound is made in rather few organisms, notably Actinobacteria and filamentous fungi.[1] Ergothioneine was discovered in 1909 and named after the ergot fungus from which it was first purified, with its structure being determined later, in 1911.[2] This amino acid has antioxidant properties, but its chemistry differs from conventional sulfur-containing antioxidants such as glutathione or lipoic acid.

Although ergothioneine cannot be made in human cells, it is present in some tissues at high levels as it is absorbed from the diet.[3] In humans ergothioneine is taken up from the gut and concentrated in some tissues by a specific transporter called ETT (gene symbol SLC22A4). However, even today, one hundred years after its discovery, precisely what ergothioneine does in the human body remains a mystery.[4][5]

Contents

Chemistry

Ergothioneine is a thiourea derivative of the betaine of histidine and contains a sulfur atom bonded to the 2-position of the imidazole ring. This compound is unusual since the sulfur atom is most stable in solution in the thione form, rather than the sulfhydryl.[6] This makes ergothioneine much less reactive than thiols such as glutathione towards alkylating agents like maleimides, and also prevents the compound from oxidizing in air.[4] However, ergothioneine can be slowly oxidized over several days to the disulfide

Ergothioneine	
	
	
IUPAC name	
3-(2-Sulfanylidene-1,3-dihydroimidazol-4-yl)-2-(trimethylazaniumyl)propanoate	
Other names	
L-Ergothioneine; (+)-Ergothioneine; Thiasine; Sympectothion; Ergothionine; Erythrothioneine; Thiolhistidinebetaine	
Identifiers	
CAS number	497-30-3 ✓
PubChem	5351619
ChemSpider	4508619 ✓
UNII	BDZ3DQM98W ✓
ChEBI	CHEBI:4828 ✓
Jmol-3D images	Image 1 (http://chemapps.stolaf.edu/jmol/jmol.php?model=C%5BN%2B%5D%28C%29%28C%29C%28CC1%3DCNC%28%3DS%29N1%29C%28%3DO%29%5BO-%5D) Image 2 (http://chemapps.stolaf.edu/jmol/jmol.php?model=S%3DC1N%5CC%28%3DC%2FN1%29C%5BC%40%40H%5D%28C%28%5BO-%5D%29%3DO%29%5BN%2B%5D%28C%29%28C%29C)
SMILES	
InChI	
Properties	

form in acidic solutions.[7] If ergothioneine does become oxidized, the disulfide is a very strong oxidizing agent, so this will in turn rapidly oxidize other thiols in the cell such as glutathione.[8]

Molecular formula	$C_9H_{15}N_3O_2S$
Molar mass	229.30 g/mol
Appearance	white solid
Melting point	275 to 277 °C (527 to 531 °F; 548 to 550 K)
Except where noted otherwise, data are given for materials in their standard state (at 25 °C (77 °F), 100 kPa)	
✓ (verify) (what is: ✓/✗?)	
Infobox references	

Metabolism and sources

Ergothioneine has been found in bacteria, plants and animals, sometimes at millimolar levels.[4] Foods rich in ergothioneine include liver, kidney, black beans, kidney bean and oat bran, with the highest levels in bolete and oyster mushrooms.[4] Levels can be variable, even within species and some tissues can contain much more than others. In the human body, the largest amounts of ergothioneine are found in erythrocytes, eye lens and semen,[2] and it is also present in the skin.[9]

Although many species contain ergothioneine, only a few can make it, the others absorb it from their diet or, in the case of plants, from their environment.[10] Biosynthesis has been detected in Actinobacteria, such as *Mycobacterium smegmatis* and filamentous fungi, such as *Neurospora crassa*.[1] Although the exact metabolic pathway is not clear, it is known that the imidazole ring is supplied by histidine, which is then methylated to produce histidine betaine, and then the sulfur atom incorporated from cysteine.[4][11] Other species of bacteria, such as *Bacillus subtilis*, *Escherichia coli*, *Proteus vulgaris* and *Streptococcus*, as well as fungi in the Saccharomycotina cannot make ergothioneine.[12][13]

Preliminary research

Ergothioneine has antioxidant properties in vitro.[1][14] Under laboratory conditions, it scavenges hydroxyl radicals and hypochlorous acid, inhibits production of oxidants by metal ions,[15][16] and may participate in metal ion transport and regulation of metalloenzymes.[16] As these properties were measured in cell-free systems, their relevance to actual function of ergothioneine in vivo remains unproven.[4]

In vitro, ergothioneine is transported into human cells by a specific transporter called ETT (gene symbol SLC22A4).[17][18] Mutants of this transporter are associated with the autoimmune disorders, rheumatoid arthritis and Crohn's disease.[4] Surprisingly, these mutant transporters are not impaired and instead can transport ergothioneine more efficiently than the normal forms of these proteins.[5] This may also relate to the fact that higher blood ergothioneine levels have been associated with rheumatoid arthritis.[19]

Since the function of ergothioneine in human metabolism remains unknown, whether these findings point to a direct role for this amino acid in human disease is unclear.[4] One human study showed pain reduction and increased range of movement over six weeks of dietary supplementation.[20]

See also

- Natural product

- Oxidative stress
- Reactive oxygen species
- Medicinal mushrooms
- Inflammation

References

1. ^ [a] [b] [c] Fahey RC (2001). "Novel thiols of prokaryotes". *Annu. Rev. Microbiol.* **55**: 333–56. doi:10.1146/annurev.micro.55.1.333 (http://dx.doi.org/10.1146%2Fannurev.micro.55.1.333). PMID 11544359 (https://www.ncbi.nlm.nih.gov/pubmed/11544359).
2. ^ [a] [b] Mann T, Leone E (January 1953). "Studies on the metabolism of semen. 8. Ergothioneine as a normal constituent of boar seminal plasma. Purification and crystallization. Site of formation and function" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1198115). *Biochem. J.* **53** (1): 140–8. PMC 1198115 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1198115). PMID 13032046 (https://www.ncbi.nlm.nih.gov/pubmed/13032046).
3. ^ Melville DB, Otken CC, Kovalenko V (September 1955). "On the origin of animal ergothioneine" (http://www.jbc.org/cgi/reprint/216/1/325). *J. Biol. Chem.* **216** (1): 325–31. PMID 13252032 (https://www.ncbi.nlm.nih.gov/pubmed/13252032).
4. ^ [a] [b] [c] [d] [e] [f] [g] [h] Ey J, Schömig E, Taubert D (August 2007). "Dietary sources and antioxidant effects of ergothioneine". *J. Agric. Food Chem.* **55** (16): 6466–74. doi:10.1021/jf071328f (http://dx.doi.org/10.1021%2Fjf071328f). PMID 17616140 (https://www.ncbi.nlm.nih.gov/pubmed/17616140).
5. ^ [a] [b] Taubert D, Grimberg G, Jung N, Rubbert A, Schömig E (October 2005). "Functional role of the 503F variant of the organic cation transporter OCTN1 in Crohn's disease" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1774715). *Gut* **54** (10): 1505–6. doi:10.1136/gut.2005.076083 (http://dx.doi.org/10.1136%2Fgut.2005.076083). PMC 1774715 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1774715). PMID 16162962 (https://www.ncbi.nlm.nih.gov/pubmed/16162962).
6. ^ Hartman PE (1990). "Ergothioneine as antioxidant". *Meth. Enzymol*. Methods in Enzymology **186**: 310–8. doi:10.1016/0076-6879(90)86124-E (http://dx.doi.org/10.1016%2F0076-6879%2890%2986124-E). ISBN 978-0-12-182087-9. PMID 2172707 (https://www.ncbi.nlm.nih.gov/pubmed/2172707).
7. ^ Heath H, Toennies G (February 1958). "The preparation and properties of ergothioneine disulphide" (http://www.biochemj.org/bj/068/0204/0680204.pdf). *Biochem. J.* **68** (2): 204–10. PMC 1200325 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1200325). PMID 13522601 (https://www.ncbi.nlm.nih.gov/pubmed/13522601).
8. ^ Hand CE, Taylor NJ, Honek JF (March 2005). "Ab initio studies of the properties of intracellular thiols ergothioneine and ovothiol". *Bioorg. Med. Chem. Lett.* **15** (5): 1357–60. doi:10.1016/j.bmcl.2005.01.014 (http://dx.doi.org/10.1016%2Fj.bmcl.2005.01.014). PMID 15713386 (https://www.ncbi.nlm.nih.gov/pubmed/15713386).
9. ^ Markova NG, Karaman-Jurukovska N, Dong KK, Damaghi N, Smiles KA, Yarosh DB. (April 2009). "Skin cells and tissue are capable of using l-ergothioneine as an integral component of their antioxidant defense system". *Free Radic Biol Med.* **46** (8): 1168–76. doi:10.1016/j.freeradbiomed.2009.01.021 (http://dx.doi.org/10.1016%2Fj.freeradbiomed.2009.01.021). PMID 19439218 (https://www.ncbi.nlm.nih.gov/pubmed/19439218).

10. ^ Audley, B.S.; Tan, C.H. (1968). "The uptake of ergothioneine from the soil into the latex of Hevea brasiliensis". *Phytochemistry* **7** (11): 1999–2000. doi:10.1016/S0031-9422(00)90759-3 (http://dx.doi.org/10.1016%2FS0031-9422%2800%2990759-3).
11. ^ Melville DB, Ludwig ML, Inamine E, Rachele JR (May 1959). "Transmethylation in the biosynthesis of ergothioneine" (http://www.jbc.org/cgi/pmidlookup?view=long&pmid=13654346). *J. Biol. Chem.* **234** (5): 1195–8. PMID 13654346 (https://www.ncbi.nlm.nih.gov/pubmed/13654346).
12. ^ Genghof DS (1 August 1970). "Biosynthesis of Ergothioneine and Hercynine by Fungi and Actinomycetales" (http://jb.asm.org/cgi/pmidlookup?view=long&pmid=5432011). *J. Bacteriol.* **103** (2): 475–8. PMC 248105 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC248105). PMID 5432011 (https://www.ncbi.nlm.nih.gov/pubmed/5432011).
13. ^ Genghof DS, Inamine E, Kovalenko V, Melville DB (November 1956). "Ergothioneine in microorganisms" (http://www.jbc.org/cgi/pmidlookup?view=long&pmid=13376573). *J. Biol. Chem.* **223** (1): 9–17. PMID 13376573 (https://www.ncbi.nlm.nih.gov/pubmed/13376573).
14. ^ Hand CE, Honek JF (February 2005). "Biological chemistry of naturally occurring thiols of microbial and marine origin". *J. Nat. Prod.* **68** (2): 293–308. doi:10.1021/np049685x (http://dx.doi.org/10.1021%2Fnp049685x). PMID 15730267 (https://www.ncbi.nlm.nih.gov/pubmed/15730267).
15. ^ Akanmu D, Cecchini R, Aruoma OI, Halliwell B (July 1991). "The antioxidant action of ergothioneine". *Arch Biochem Biophys* **288** (1): 10–6. doi:10.1016/0003-9861(91)90158-F (http://dx.doi.org/10.1016%2F0003-9861%2891%2990158-F). PMID 1654816 (https://www.ncbi.nlm.nih.gov/pubmed/1654816).
16. ^ *a b* Misiti F, Castagnola M, Zuppi C, Giardina B, Messana I (June 2001). "Role of ergothioneine on S-nitrosoglutathione catabolism" (http://www.biochemj.org/bj/356/0799/bj3560799.htm). *Biochem J* **356** (Pt 3): 799–804. doi:10.1042/0264-6021:3560799 (http://dx.doi.org/10.1042%2F0264-6021%3A3560799). PMC 1221906 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1221906). PMID 11389687 (https://www.ncbi.nlm.nih.gov/pubmed/11389687).
17. ^ Gründemann D, Harlfinger S, Golz S, *et al.* (2005). "Discovery of the ergothioneine transporter" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC555966). *Proc. Natl. Acad. Sci. U.S.A.* **102** (14): 5256–61. doi:10.1073/pnas.0408624102 (http://dx.doi.org/10.1073%2Fpnas.0408624102). PMC 555966 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC555966). PMID 15795384 (https://www.ncbi.nlm.nih.gov/pubmed/15795384).
18. ^ Nakamura T, Yoshida K, Yabuuchi H, Maeda T, Tamai I (August 2008). "Functional characterization of ergothioneine transport by rat organic cation/carnitine transporter Octn1 (slc22a4)" (http://joi.jlc.jst.go.jp/JST.JSTAGE/bpb/31.1580?from=PubMed) (– Scholar search (http://scholar.google.co.uk/scholar?hl=en&lr=&q=intitle%3AFunctional+characterization+of+ergothioneine+transport+by+rat+organic+cation%2Fcarnitine+transporter+Octn1+%28slc22a4%29&as_publication=Biol.+Pharm.+Bull.&as_ylo=2008&as_yhi=2008&btnG=Search)). *Biol. Pharm. Bull.* **31** (8): 1580–4. doi:10.1248/bpb.31.1580 (http://dx.doi.org/10.1248%2Fbpb.31.1580). PMID 18670092 (https://www.ncbi.nlm.nih.gov/pubmed/18670092).
19. ^ Taubert D, Lazar A, Grimberg G, *et al* (November 2006). "Association of rheumatoid arthritis with ergothioneine levels in red blood cells: a case control study" (http://www.jrheum.org/cgi/pmidlookup?view=long&pmid=17086603). *J. Rheumatol.* **33** (11): 2139–45. PMID 17086603 (https://www.ncbi.nlm.nih.gov/pubmed/17086603).

20. ^ Benson K, Ager D, Landes B, *et al* (May 2012). "Improvement of joint range of motion (ROM) and reduction of chronic pain after consumption of an ergothioneine-containing nutritional supplement" (http://www.sciencedirect.com/science/article/pii/S0091743512000448). *Preventive Medicine* **54**: S83–9. doi:10.1016/j.ypmed.2012.02.001 (http://dx.doi.org/10.1016%2Fj.ypmed.2012.02.001). PMID 22342951 (https://www.ncbi.nlm.nih.gov/pubmed/22342951).

External links

- Ergothioneine (http://www.hmdb.ca/metabolites/HMDB03045) Human Metabolome Database
- Ergothioneine (http://www.genome.jp/dbget-bin/www_bget?compound+C05570) KEGG Compound
- Ergothioneine (http://www.tetrahedron.fr/page2/page7/ergothioneine.htm) TETRAHEDRON

Retrieved from "http://en.wikipedia.org/w/index.php?title=Ergothioneine&oldid=603306588"
Categories: Thioureas | Amino acids | Imidazolines

Shortcut Text	Internet Address
navigation	http://en.wikipedia.org/wiki/Ergothioneine#mw-navigation
search	http://en.wikipedia.org/wiki/Ergothioneine#p-search
	http://en.wikipedia.org/wiki/File:Ergothioneine.svg
	http://en.wikipedia.org/wiki/File:Ergothioneine_ball_and_stick.png
	http://en.wikipedia.org/wiki/File:Ergothioneine_3D.png
IUPAC name	http://en.wikipedia.org/wiki/International_Union_of_Pure_and_Applied_
[hide]	http://en.wikipedia.org/wiki/Ergothioneine#
CAS number	http://en.wikipedia.org/wiki/CAS_registry_number
497-30-3	http://www.commonchemistry.org/ChemicalDetail.aspx?ref=497-30-3
PubChem	http://en.wikipedia.org/wiki/PubChem
5351619	http://pubchem.ncbi.nlm.nih.gov/summary/summary.cgi?cid=5351619
ChemSpider	http://en.wikipedia.org/wiki/ChemSpider
4508619	http://www.chemspider.com/Chemical-Structure.4508619.html
UNII	http://en.wikipedia.org/wiki/Unique_Ingredient_Identifier
BDZ3DQM98W	http://fdasis.nlm.nih.gov/srs/srsdirect.jsp?regno=BDZ3DQM98W
ChEBI	http://en.wikipedia.org/wiki/ChEBI
CHEBI:4828	https://www.ebi.ac.uk/chebi/searchId.do?chebiId=4828
Jmol	http://en.wikipedia.org/wiki/Jmol
Image 1	http://chemapps.stolaf.edu/jmol/jmol.php?model=C%5BN%2B%5D%28 28CC1%3DCNC%28%3DS%29N1%29C%28%3DO%29%5BO-%5D
Image 2	http://chemapps.stolaf.edu/jmol/jmol.php?model=S%3DC1N%5CC%28 5BC%40%40H%5D%28C%28%5BO-%5D%29%3DO%29%5BN%2B% 29C
SMILES	http://en.wikipedia.org/wiki/Simplified_molecular-input_line-entry_syste
InChI	http://en.wikipedia.org/wiki/International_Chemical_Identifier
Molecular formula	http://en.wikipedia.org/wiki/Chemical_formula
Molar mass	http://en.wikipedia.org/wiki/Molar_mass
Melting point	http://en.wikipedia.org/wiki/Melting_point
standard state	http://en.wikipedia.org/wiki/Standard_state
(verify)	http://en.wikipedia.org/w/index.php? title=Special:ComparePages&rev1=443735061&page2=Ergothioneine
(what is:	http://en.wikipedia.org/wiki/Wikipedia:WikiProject_Chemicals/Chembox
Infobox references	http://en.wikipedia.org/wiki/Wikipedia:Chemical_infobox#References
amino acid	http://en.wikipedia.org/wiki/Amino_acid
sulfur	http://en.wikipedia.org/wiki/Sulfur
imidazole	http://en.wikipedia.org/wiki/Imidazole
Actinobacteria	http://en.wikipedia.org/wiki/Actinobacteria
[1]	http://en.wikipedia.org/wiki/Ergothioneine#cite_note-Fahey-1
ergot	http://en.wikipedia.org/wiki/Ergot
[2]	http://en.wikipedia.org/wiki/Ergothioneine#cite_note-Mann-2
antioxidant	http://en.wikipedia.org/wiki/Antioxidant

Shortcut Text	Internet Address
glutathione	http://en.wikipedia.org/wiki/Glutathione
lipoic acid	http://en.wikipedia.org/wiki/Lipoic_acid
[3]	http://en.wikipedia.org/wiki/Ergothioneine#cite_note-3
SLC22A4	http://en.wikipedia.org/wiki/SLC22A4
[4]	http://en.wikipedia.org/wiki/Ergothioneine#cite_note-Schomig-4
[5]	http://en.wikipedia.org/wiki/Ergothioneine#cite_note-Taubert-5
1 Chemistry	http://en.wikipedia.org/wiki/Ergothioneine#Chemistry
2 Metabolism and sources	http://en.wikipedia.org/wiki/Ergothioneine#Metabolism_and_sources
3 Preliminary research	http://en.wikipedia.org/wiki/Ergothioneine#Preliminary_research
4 See also	http://en.wikipedia.org/wiki/Ergothioneine#See_also
5 References	http://en.wikipedia.org/wiki/Ergothioneine#References
6 External links	http://en.wikipedia.org/wiki/Ergothioneine#External_links
edit	http://en.wikipedia.org/w/index.php?title=Ergothioneine&action=edit§io
thiourea	http://en.wikipedia.org/wiki/Thiourea
betaine	http://en.wikipedia.org/wiki/Betaine
histidine	http://en.wikipedia.org/wiki/Histidine
thione	http://en.wikipedia.org/wiki/Thione
sulfhydryl	http://en.wikipedia.org/wiki/Sulfhydryl
[6]	http://en.wikipedia.org/wiki/Ergothioneine#cite_note-6
maleimides	http://en.wikipedia.org/wiki/Maleimide
oxidizing	http://en.wikipedia.org/wiki/Redox
disulfide	http://en.wikipedia.org/wiki/Disulfide
[7]	http://en.wikipedia.org/wiki/Ergothioneine#cite_note-7
[8]	http://en.wikipedia.org/wiki/Ergothioneine#cite_note-8
edit	http://en.wikipedia.org/w/index.php?title=Ergothioneine&action=edit§io
millimolar	http://en.wikipedia.org/wiki/Molarity
liver	http://en.wikipedia.org/wiki/Liver
kidney	http://en.wikipedia.org/wiki/Kidney
black beans	http://en.wikipedia.org/wiki/Black_beans
kidney bean	http://en.wikipedia.org/wiki/Kidney_bean
oat bran	http://en.wikipedia.org/wiki/Oat_bran
bolete	http://en.wikipedia.org/wiki/Bolete
oyster mushrooms	http://en.wikipedia.org/wiki/Oyster_mushroom
erythrocytes	http://en.wikipedia.org/wiki/Erythrocyte
eye lens	http://en.wikipedia.org/wiki/Lens_(anatomy)
semen	http://en.wikipedia.org/wiki/Semen
skin	http://en.wikipedia.org/wiki/Skin
[9]	http://en.wikipedia.org/wiki/Ergothioneine#cite_note-9
[10]	http://en.wikipedia.org/wiki/Ergothioneine#cite_note-10
Mycobacterium smegmatis	http://en.wikipedia.org/wiki/Mycobacterium_smegmatis
Neurospora crassa	

Shortcut Text	Internet Address
	http://en.wikipedia.org/wiki/Neurospora_crassa
metabolic pathway	http://en.wikipedia.org/wiki/Metabolic_pathway
methylated	http://en.wikipedia.org/wiki/Methylation
[11]	http://en.wikipedia.org/wiki/Ergothioneine#cite_note-11
Bacillus subtilis	http://en.wikipedia.org/wiki/Bacillus_subtilis
Escherichia coli	http://en.wikipedia.org/wiki/Escherichia_coli
Proteus vulgaris	http://en.wikipedia.org/wiki/Proteus_vulgaris
Streptococcus	http://en.wikipedia.org/wiki/Streptococcus
Saccharomycotina	http://en.wikipedia.org/wiki/Saccharomycotina
[12]	http://en.wikipedia.org/wiki/Ergothioneine#cite_note-12
[13]	http://en.wikipedia.org/wiki/Ergothioneine#cite_note-13
edit	http://en.wikipedia.org/w/index.php?title=Ergothioneine&action=edit§io
in vitro	http://en.wikipedia.org/wiki/In_vitro
[14]	http://en.wikipedia.org/wiki/Ergothioneine#cite_note-14
hydroxyl radicals	http://en.wikipedia.org/wiki/Hydroxyl_radical
hypochlorous acid	http://en.wikipedia.org/wiki/Hypochlorous_acid
[15]	http://en.wikipedia.org/wiki/Ergothioneine#cite_note-15
[16]	http://en.wikipedia.org/wiki/Ergothioneine#cite_note-Misiti-16
metalloenzymes	http://en.wikipedia.org/wiki/Metalloenzyme
in vivo	http://en.wikipedia.org/wiki/In_vivo
[17]	http://en.wikipedia.org/wiki/Ergothioneine#cite_note-17
[18]	http://en.wikipedia.org/wiki/Ergothioneine#cite_note-18
rheumatoid arthritis	http://en.wikipedia.org/wiki/Rheumatoid_arthritis
Crohn's disease	http://en.wikipedia.org/wiki/Crohn%27s_disease
[19]	http://en.wikipedia.org/wiki/Ergothioneine#cite_note-19
metabolism	http://en.wikipedia.org/wiki/Metabolism
pain	http://en.wikipedia.org/wiki/Pain
[20]	http://en.wikipedia.org/wiki/Ergothioneine#cite_note-20
edit	http://en.wikipedia.org/w/index.php?title=Ergothioneine&action=edit§io
Natural product	http://en.wikipedia.org/wiki/Natural_product
Oxidative stress	http://en.wikipedia.org/wiki/Oxidative_stress
Reactive oxygen species	http://en.wikipedia.org/wiki/Reactive_oxygen_species
Medicinal mushrooms	http://en.wikipedia.org/wiki/Medicinal_mushrooms
Inflammation	http://en.wikipedia.org/wiki/Inflammation
edit	http://en.wikipedia.org/w/index.php?title=Ergothioneine&action=edit§io
a	http://en.wikipedia.org/wiki/Ergothioneine#cite_ref-Fahey_1-0
b	http://en.wikipedia.org/wiki/Ergothioneine#cite_ref-Fahey_1-1
c	http://en.wikipedia.org/wiki/Ergothioneine#cite_ref-Fahey_1-2
doi	http://en.wikipedia.org/wiki/Digital_object_identifier
10.1146/annurev.micro.55.1.333	http://dx.doi.org/10.1146%2Fannurev.micro.55.1.333
PMID	

Shortcut Text	Internet Address
	http://en.wikipedia.org/wiki/PubMed_Identifier
11544359	http://www.ncbi.nlm.nih.gov/pubmed/11544359
a	http://en.wikipedia.org/wiki/Ergothioneine#cite_ref-Mann_2-0
b	http://en.wikipedia.org/wiki/Ergothioneine#cite_ref-Mann_2-1
"Studies on the metabolism of semen. 8. Ergothioneine as a normal constituent of boar seminal plasma. Purification and crystallization. Site of formation and function"	http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1198115
PMC	http://en.wikipedia.org/wiki/PubMed_Central
13032046	http://www.ncbi.nlm.nih.gov/pubmed/13032046
^	http://en.wikipedia.org/wiki/Ergothioneine#cite_ref-3
"On the origin of animal ergothioneine"	http://www.jbc.org/cgi/reprint/216/1/325
13252032	http://www.ncbi.nlm.nih.gov/pubmed/13252032
a	http://en.wikipedia.org/wiki/Ergothioneine#cite_ref-Schomig_4-0
b	http://en.wikipedia.org/wiki/Ergothioneine#cite_ref-Schomig_4-1
c	http://en.wikipedia.org/wiki/Ergothioneine#cite_ref-Schomig_4-2
d	http://en.wikipedia.org/wiki/Ergothioneine#cite_ref-Schomig_4-3
e	http://en.wikipedia.org/wiki/Ergothioneine#cite_ref-Schomig_4-4
f	http://en.wikipedia.org/wiki/Ergothioneine#cite_ref-Schomig_4-5
g	http://en.wikipedia.org/wiki/Ergothioneine#cite_ref-Schomig_4-6
h	http://en.wikipedia.org/wiki/Ergothioneine#cite_ref-Schomig_4-7
10.1021/jf071328f	http://dx.doi.org/10.1021%2Fjf071328f
17616140	http://www.ncbi.nlm.nih.gov/pubmed/17616140
a	http://en.wikipedia.org/wiki/Ergothioneine#cite_ref-Taubert_5-0
b	http://en.wikipedia.org/wiki/Ergothioneine#cite_ref-Taubert_5-1
"Functional role of the 503F variant of the organic cation transporter OCTN1 in Crohn's disease"	http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1774715
10.1136/gut.2005.076083	http://dx.doi.org/10.1136%2Fgut.2005.076083
16162962	http://www.ncbi.nlm.nih.gov/pubmed/16162962
^	http://en.wikipedia.org/wiki/Ergothioneine#cite_ref-6
10.1016/0076-6879(90)86124-E	http://dx.doi.org/10.1016%2F0076-6879%2890%2986124-E
ISBN	http://en.wikipedia.org/wiki/International_Standard_Book_Number
978-0-12-182087-9	http://en.wikipedia.org/wiki/Special:BookSources/978-0-12-182087-9
2172707	http://www.ncbi.nlm.nih.gov/pubmed/2172707
^	http://en.wikipedia.org/wiki/Ergothioneine#cite_ref-7
"The preparation and properties of ergothioneine disulphide"	http://www.biochemj.org/bj/068/0204/0680204.pdf
1200325	http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1200325
13522601	http://www.ncbi.nlm.nih.gov/pubmed/13522601

Shortcut Text	Internet Address
^	http://en.wikipedia.org/wiki/Ergothioneine#cite_ref-8
10.1016/j.bmcl.2005.01.014	http://dx.doi.org/10.1016%2Fj.bmcl.2005.01.014
15713386	http://www.ncbi.nlm.nih.gov/pubmed/15713386
^	http://en.wikipedia.org/wiki/Ergothioneine#cite_ref-9
10.1016/j.freeradbiomed.2009.01.021	http://dx.doi.org/10.1016%2Fj.freeradbiomed.2009.01.021
19439218	http://www.ncbi.nlm.nih.gov/pubmed/19439218
^	http://en.wikipedia.org/wiki/Ergothioneine#cite_ref-10
10.1016/S0031-9422(00)90759-3	http://dx.doi.org/10.1016%2FS0031-9422%2800%2990759-3
^	http://en.wikipedia.org/wiki/Ergothioneine#cite_ref-11
"Transmethylation in the biosynthesis of ergothioneine"	http://www.jbc.org/cgi/pmidlookup?view=long&pmid=13654346
13654346	http://www.ncbi.nlm.nih.gov/pubmed/13654346
^	http://en.wikipedia.org/wiki/Ergothioneine#cite_ref-12
"Biosynthesis of Ergothioneine and Hercynine by Fungi and Actinomycetales"	http://jb.asm.org/cgi/pmidlookup?view=long&pmid=5432011
248105	http://www.ncbi.nlm.nih.gov/pmc/articles/PMC248105
5432011	http://www.ncbi.nlm.nih.gov/pubmed/5432011
^	http://en.wikipedia.org/wiki/Ergothioneine#cite_ref-13
"Ergothioneine in microorganisms"	http://www.jbc.org/cgi/pmidlookup?view=long&pmid=13376573
13376573	http://www.ncbi.nlm.nih.gov/pubmed/13376573
^	http://en.wikipedia.org/wiki/Ergothioneine#cite_ref-14
10.1021/np049685x	http://dx.doi.org/10.1021%2Fnp049685x
15730267	http://www.ncbi.nlm.nih.gov/pubmed/15730267
^	http://en.wikipedia.org/wiki/Ergothioneine#cite_ref-15
10.1016/0003-9861(91)90158-F	http://dx.doi.org/10.1016%2F0003-9861%2891%2990158-F
1654816	http://www.ncbi.nlm.nih.gov/pubmed/1654816
a	http://en.wikipedia.org/wiki/Ergothioneine#cite_ref-Misiti_16-0
b	http://en.wikipedia.org/wiki/Ergothioneine#cite_ref-Misiti_16-1
"Role of ergothioneine on S-nitrosoglutathione catabolism"	http://www.biochemj.org/bj/356/0799/bj3560799.htm
10.1042/0264-6021:3560799	http://dx.doi.org/10.1042%2F0264-6021%3A3560799
1221906	http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1221906
11389687	http://www.ncbi.nlm.nih.gov/pubmed/11389687
^	http://en.wikipedia.org/wiki/Ergothioneine#cite_ref-17
"Discovery of the ergothioneine transporter"	http://www.ncbi.nlm.nih.gov/pmc/articles/PMC555966
10.1073/pnas.0408624102	http://dx.doi.org/10.1073%2Fpnas.0408624102
15795384	http://www.ncbi.nlm.nih.gov/pubmed/15795384
^	http://en.wikipedia.org/wiki/Ergothioneine#cite_ref-18
"Functional characterization of ergothioneine transport by rat organic	http://joi.jlc.jst.go.jp/JST.JSTAGE/bpb/31.1580?from=PubMed

Shortcut Text	Internet Address
cation/carnitine transporter Octn1 (slc22a4)"	
Scholar search	http://scholar.google.co.uk/scholar?hl=en&lr=&q=intitle%3AFunctional+characterization+of+ergothioneine+transport+by+rat+orga 2Fcarnitine+transporter+Octn1+%28slc22a4%29&as_publication=Biol.+Pharm.+Bull.&as_ylo=2008&as_yhi=2008&b
10.1248/bpb.31.1580	http://dx.doi.org/10.1248%2Fbpb.31.1580
18670092	http://www.ncbi.nlm.nih.gov/pubmed/18670092
dead link	http://en.wikipedia.org/wiki/Wikipedia:Link_rot
^	http://en.wikipedia.org/wiki/Ergothioneine#cite_ref-19
"Association of rheumatoid arthritis with ergothioneine levels in red blood cells: a case control study"	http://www.jrheum.org/cgi/pmidlookup?view=long&pmid=17086603
17086603	http://www.ncbi.nlm.nih.gov/pubmed/17086603
^	http://en.wikipedia.org/wiki/Ergothioneine#cite_ref-20
"Improvement of joint range of motion (ROM) and reduction of chronic pain after consumption of an ergothioneine-containing nutritional supplement"	http://www.sciencedirect.com/science/article/pii/S0091743512000448
10.1016/j.ypmed.2012.02.001	http://dx.doi.org/10.1016%2Fj.ypmed.2012.02.001
22342951	http://www.ncbi.nlm.nih.gov/pubmed/22342951
edit	http://en.wikipedia.org/w/index.php?title=Ergothioneine&action=edit§io
Ergothioneine	http://www.hmdb.ca/metabolites/HMDB03045
Ergothioneine	http://www.genome.jp/dbget-bin/www_bget?compound+C05570
Ergothioneine	http://www.tetrahedron.fr/page2/page7/ergothioneine.htm
http://en.wikipedia.org/w/index.php?title=Ergothioneine&oldid=603306588	http://en.wikipedia.org/w/index.php?title=Ergothioneine&oldid=6033065
Categories	http://en.wikipedia.org/wiki/Help:Category
Thioureas	http://en.wikipedia.org/wiki/Category:Thioureas
Amino acids	http://en.wikipedia.org/wiki/Category:Amino_acids
Imidazolines	http://en.wikipedia.org/wiki/Category:Imidazolines
All articles with dead external links	http://en.wikipedia.org/wiki/Category:All_articles_with_dead_external_l
Articles with dead external links from April 2009	http://en.wikipedia.org/wiki/Category:Articles_with_dead_external_links
Chemboxes with conversion issues	http://en.wikipedia.org/wiki/Category:Chemboxes_with_conversion_issu
Chemical pages with an eponymous image available	http://en.wikipedia.org/wiki/Category:Chemical_pages_with_an_eponym
Chemboxes which contain changes to watched fields	http://en.wikipedia.org/wiki/Category:Chemboxes_which_contain_chang
Create account	http://en.wikipedia.org/w/index.php?title=Special:UserLogin&returnto=Ergothioneine&type=signup
Log in	http://en.wikipedia.org/w/index.php?title=Special:UserLogin&returnto=E
Article	http://en.wikipedia.org/wiki/Ergothioneine
Talk	http://en.wikipedia.org/wiki/Talk:Ergothioneine

Shortcut Text	Internet Address
Edit	http://en.wikipedia.org/w/index.php?title=Ergothioneine&action=edit
View history	http://en.wikipedia.org/w/index.php?title=Ergothioneine&action=history
	http://en.wikipedia.org/wiki/Main_Page
Contents	http://en.wikipedia.org/wiki/Portal:Contents
Featured content	http://en.wikipedia.org/wiki/Portal:Featured_content
Current events	http://en.wikipedia.org/wiki/Portal:Current_events
Random article	http://en.wikipedia.org/wiki/Special:Random
Donate to Wikipedia	https://donate.wikimedia.org/wiki/Special:FundraiserRedirector?utm_source=donate&utm_medium=sidebar&utm_campaign=C13_en.wil
Wikimedia Shop	http://shop.wikimedia.org/
Help	http://en.wikipedia.org/wiki/Help:Contents
About Wikipedia	http://en.wikipedia.org/wiki/Wikipedia:About
Community portal	http://en.wikipedia.org/wiki/Wikipedia:Community_portal
Recent changes	http://en.wikipedia.org/wiki/Special:RecentChanges
Contact page	http://en.wikipedia.org/wiki/Wikipedia:Contact_us
What links here	http://en.wikipedia.org/wiki/Special:WhatLinksHere/Ergothioneine
Related changes	http://en.wikipedia.org/wiki/Special:RecentChangesLinked/Ergothionein
Upload file	http://en.wikipedia.org/wiki/Wikipedia:File_Upload_Wizard
Special pages	http://en.wikipedia.org/wiki/Special:SpecialPages
Page information	http://en.wikipedia.org/w/index.php?title=Ergothioneine&action=info
Data item	http://www.wikidata.org/wiki/Q614788
Cite this page	http://en.wikipedia.org/w/index.php?title=Special:Cite&page=Ergothione
Create a book	http://en.wikipedia.org/w/index.php?title=Special:Book&bookcmd=book_creator&referer=Ergothioneine
Download as PDF	http://en.wikipedia.org/w/index.php?title=Special:Book&bookcmd=render_article&arttitle=Ergothioneine&ol
Printable version	http://en.wikipedia.org/w/index.php?title=Ergothioneine&printable=yes
Español	http://es.wikipedia.org/wiki/Ergotioneina
فارسی	http://fa.wikipedia.org/wiki/%D8%A7%D8%B1%DA%AF%D9%88%D88%D9%86%DB%8C%D9%86
Français	http://fr.wikipedia.org/wiki/Ergothion%C3%A9ine
Italiano	http://it.wikipedia.org/wiki/Ergotioneina
Српски / srpski	http://sr.wikipedia.org/wiki/Ergotionein
Srpskohrvatski / српскохрватски	http://sh.wikipedia.org/wiki/Ergotionein
Edit links	http://www.wikidata.org/wiki/Q614788#sitelinks-wikipedia
Creative Commons Attribution-ShareAlike License	http://en.wikipedia.org/wiki/Wikipedia:Text_of_Creative_Commons_AttShareAlike_3.0_Unported_License
	http://creativecommons.org/licenses/by-sa/3.0/
Terms of Use	http://wikimediafoundation.org/wiki/Terms_of_Use
Privacy Policy	http://wikimediafoundation.org/wiki/Privacy_policy
Wikimedia Foundation, Inc.	http://www.wikimediafoundation.org/
Disclaimers	http://en.wikipedia.org/wiki/Wikipedia:General_disclaimer

Shortcut Text	Internet Address
Developers	https://www.mediawiki.org/wiki/Special:MyLanguage/How_to_contribu
Mobile view	http://en.m.wikipedia.org/wiki/Ergothioneine
	http://wikimediafoundation.org/
	http://www.mediawiki.org/