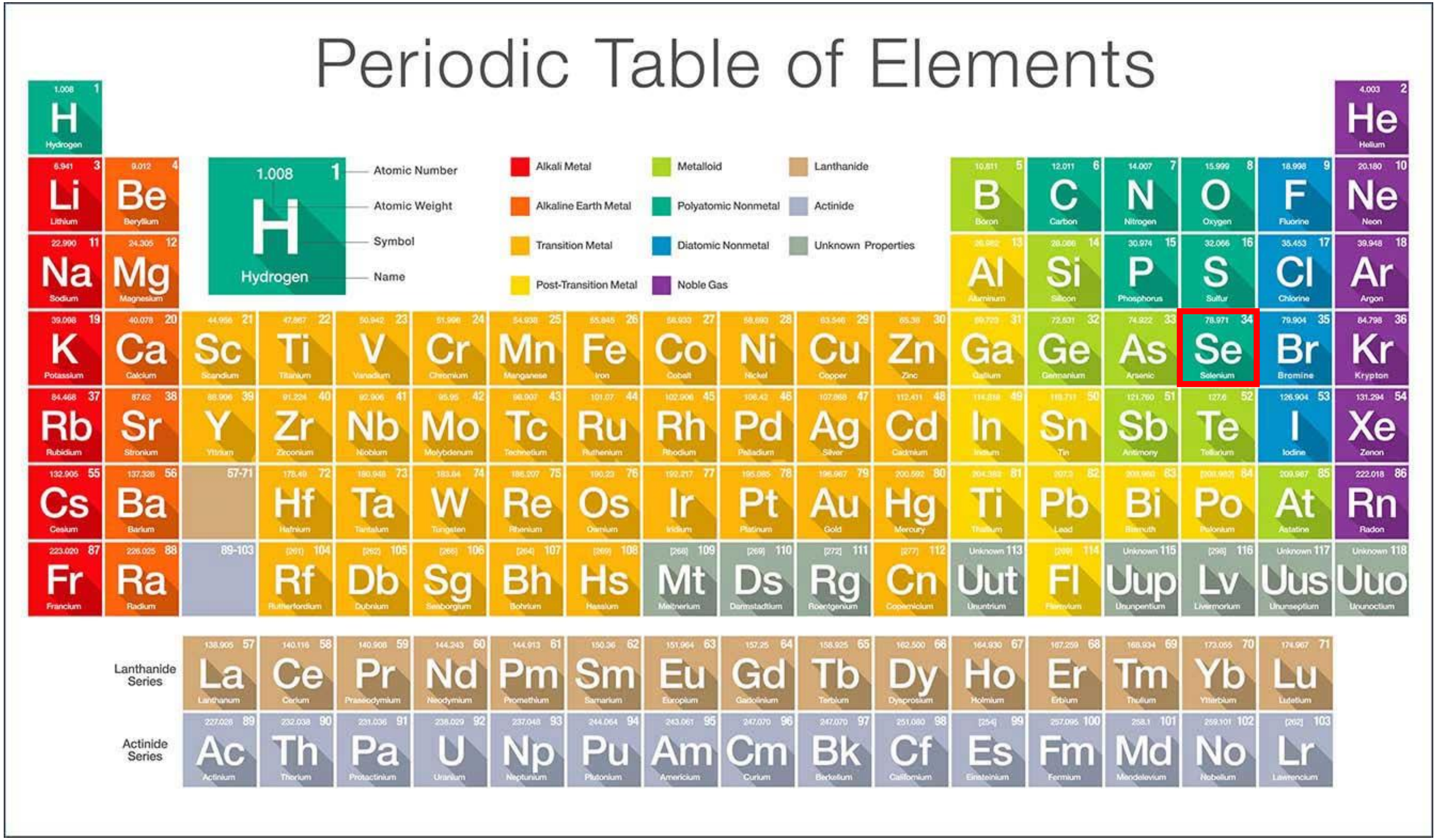
سلنیوم در تغذیه طیور

Speaker: M. Zaghari

Available at www.minatoyoor.com

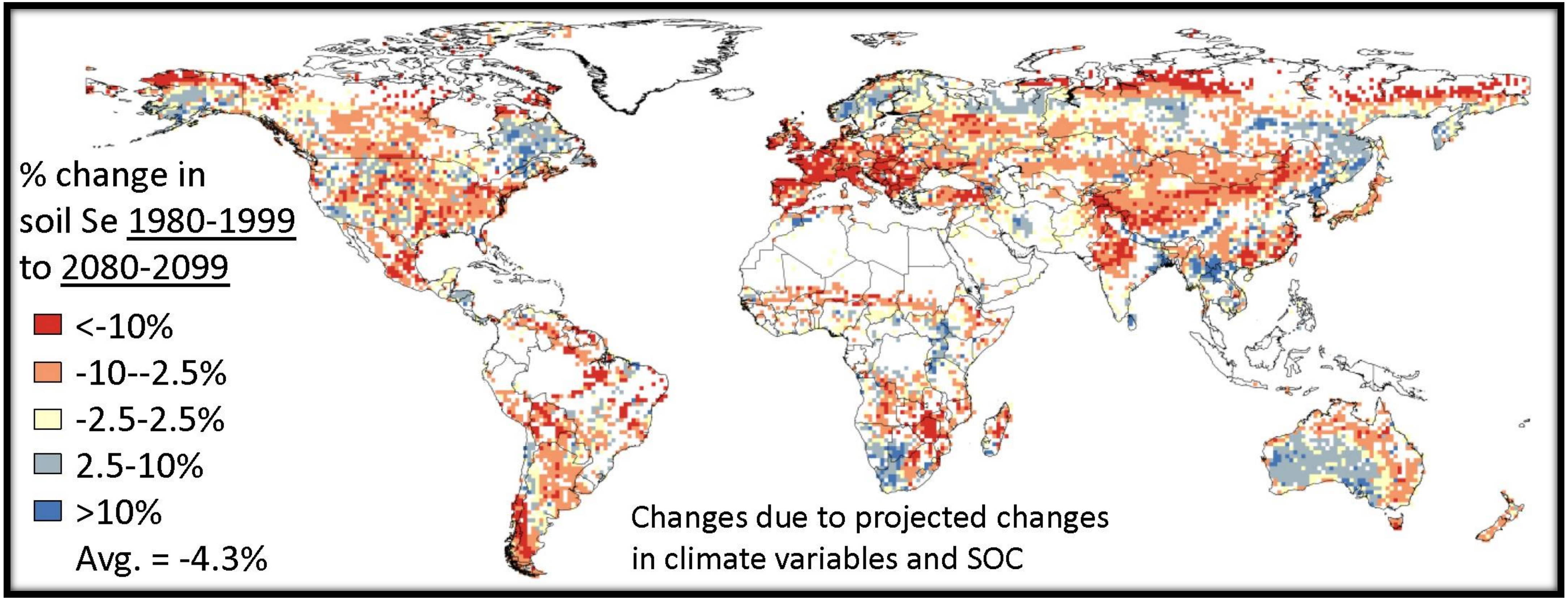

Periodic Table of Elements
1.008
1
H
Hydrogen
Atomic Number
Atomic Weight
Symbol
Name
Alkali Metal
Alkaline Earth Metal
Transition Metal
Post-Transition Metal
Metalloid
Polyatomic Nonmetal
Diatomic Nonmetal
Noble Gas
Lanthanide
Actinide
Unknown Properties
H He
Li Be B C N O F Ne
Na Mg Al Si P S Cl Ar
K Ca Sc Ti V Cr Mn Fe Co Ni Cu Zn Ga Ge As Se Br Kr
Rb Sr Y Zr Nb Mo Tc Ru Rh Pd Ag Cd In Sn Sb Te I Xe
Cs Ba 57-71 Hf Ta W Re Os Ir Pt Au Hg Tl Pb Bi Po At Rn
Fr Ra 89-103 Rf Db Sg Bh Hs Mt Ds Rg Cn Uut Fl Uup Lv Uus Uuo
Lanthanide Series
La Ce Pr Nd Pm Sm Eu Gd Tb Dy Ho Er Tm Yb Lu
Actinide Series
Ac Th Pa U Np Pu Am Cm Bk Cf Es Fm Md No Lr


34
Se
Selenium
78.96

Jöns Jacob Berzelius (1779–1848)

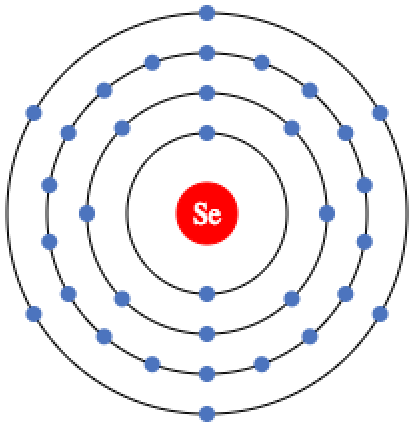
Born	20 August 1779 Väversunda, Östergötland, Sweden
Died	7 August 1848 (aged 68) Stockholm, Sweden
Nationality	Sweden
Alma mater	Uppsala University
Known for	Atomic weights Chemical notation catalysis Silicon Selenium Thorium Cerium
Awards	Copley medal (1836)
Scientific career	
Fields	Chemistry
Institutions	Karolinska Institute
Doctoral advisor	Johann Afzelius
Doctoral students	James Finlay Weir Johnston Heinrich Rose


BERZELIUS



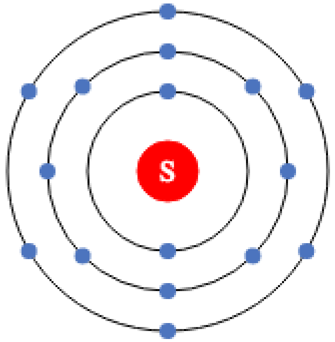
% change in
soil Se 1980-1999
to 2080-2099
<-10%
-10--2.5%
-2.5-2.5%
2.5-10%
>10%
Avg. = -4.3%
Changes due to projected changes
in climate variables and SOC

34: Selenium



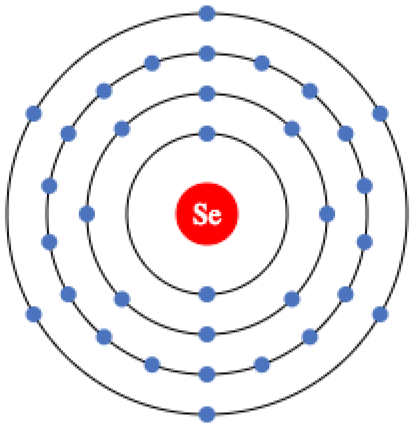
[2, 8, 18, 6]

16: Sulfur



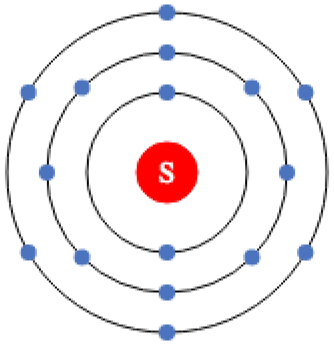
[2, 8, 6]

34: Selenium



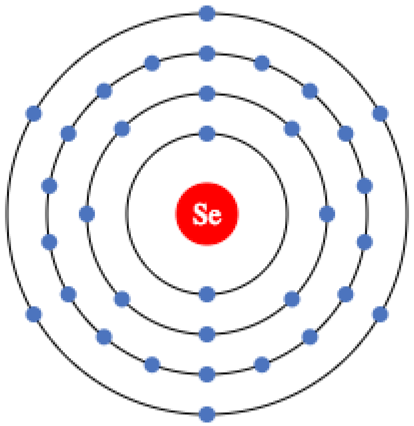
[2, 8, 18, 6]

16: Sulfur



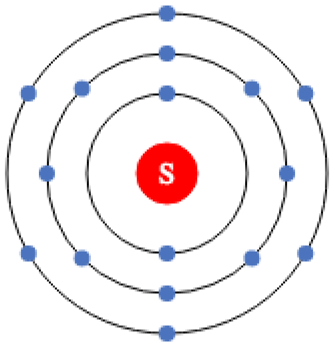
[2, 8, 6]

34: Selenium



[2, 8, 18, 6]

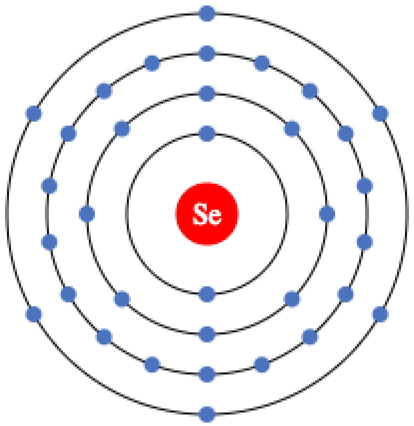
16: Sulfur

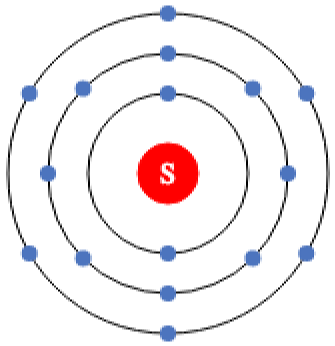


[2, 8, 6]

34: Selenium

16: Sulfur



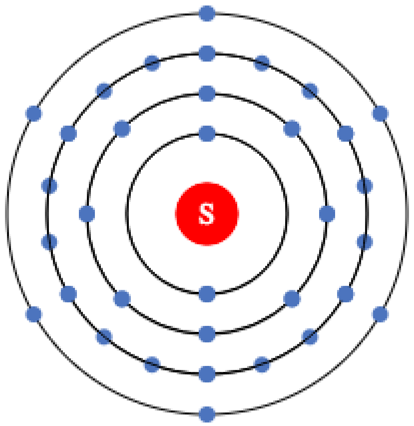


[2, 8, 6]

[2, 8, 18, 6]

34: Selenium

16: Sulfur



[2, 8, 6]

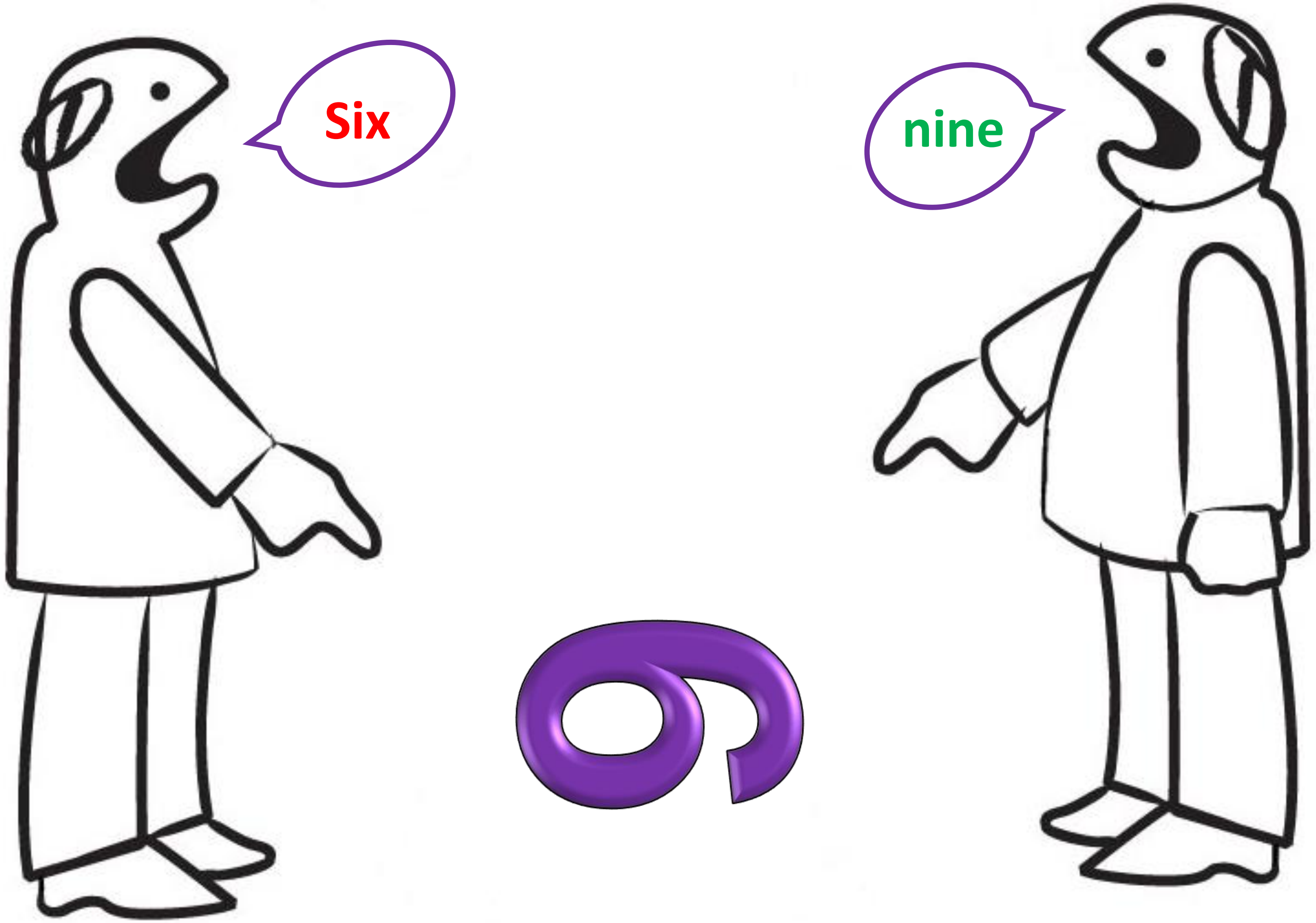
[2, 8, 18, 6]

- The discovery of Se essentiality in early 1960s.
- The discovery in 1973 that glutathione peroxidase is a selenoprotein.
- Characterisation of main selenoproteins in nutrition and health in 2003.

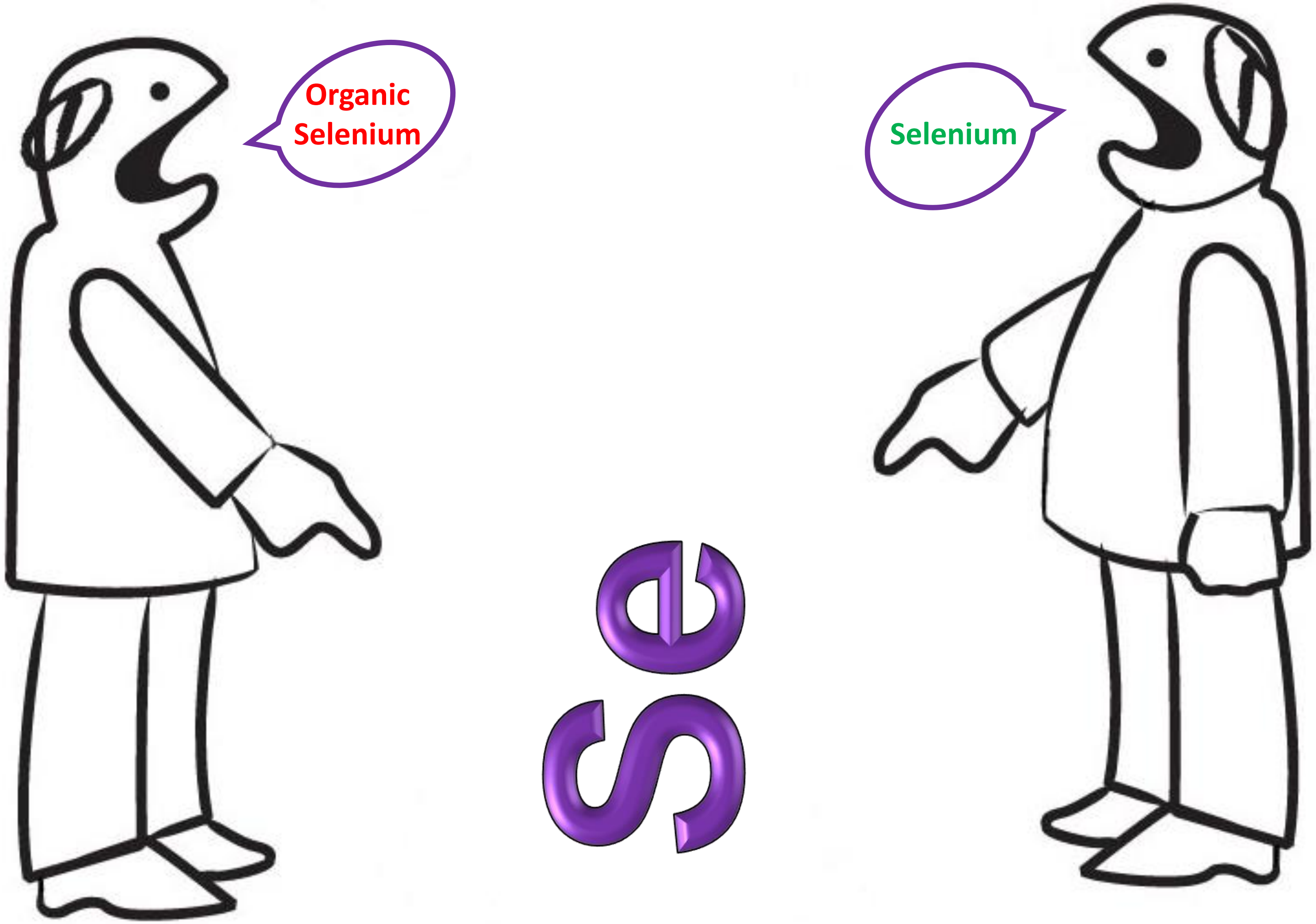
New insight

The role of free radicals as signalling molecules, understanding the role of nutrients in gene expression and maternal programming, tremendous progress in human and animal genome.

What is this?

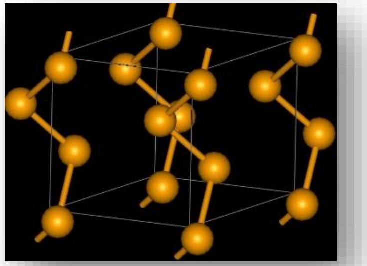


What is this?



- Elemental selenium

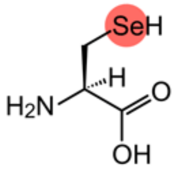
Se^0



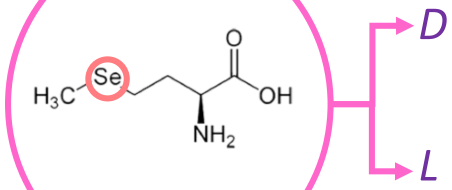
- Inorganic selenium compounds

Selenite (SeO_3^{--}), Selenate (SeO_4^{--}), Selenide (Se^{--})

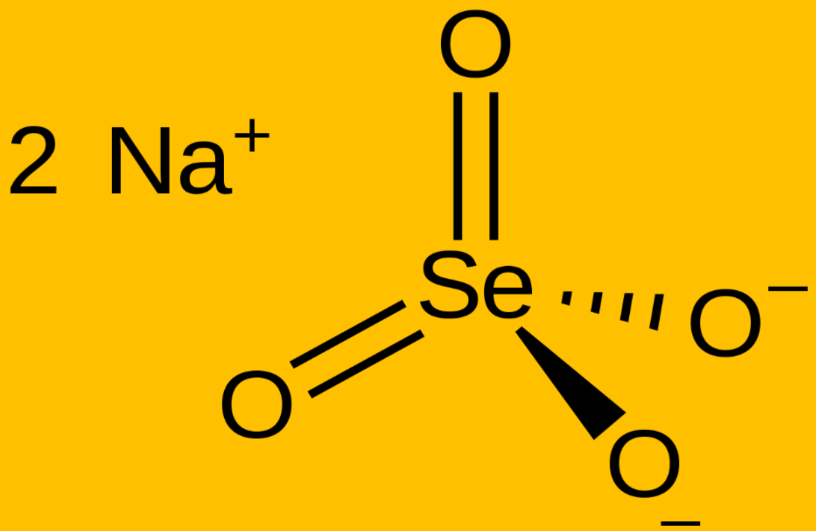
- Organic selenium compounds



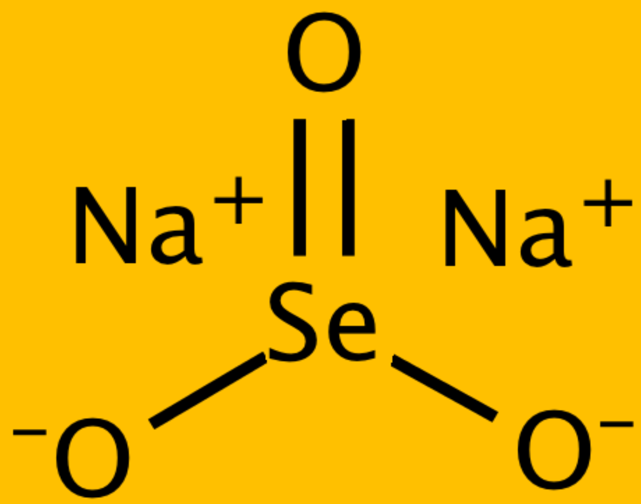
Se-Cys



Se-Met

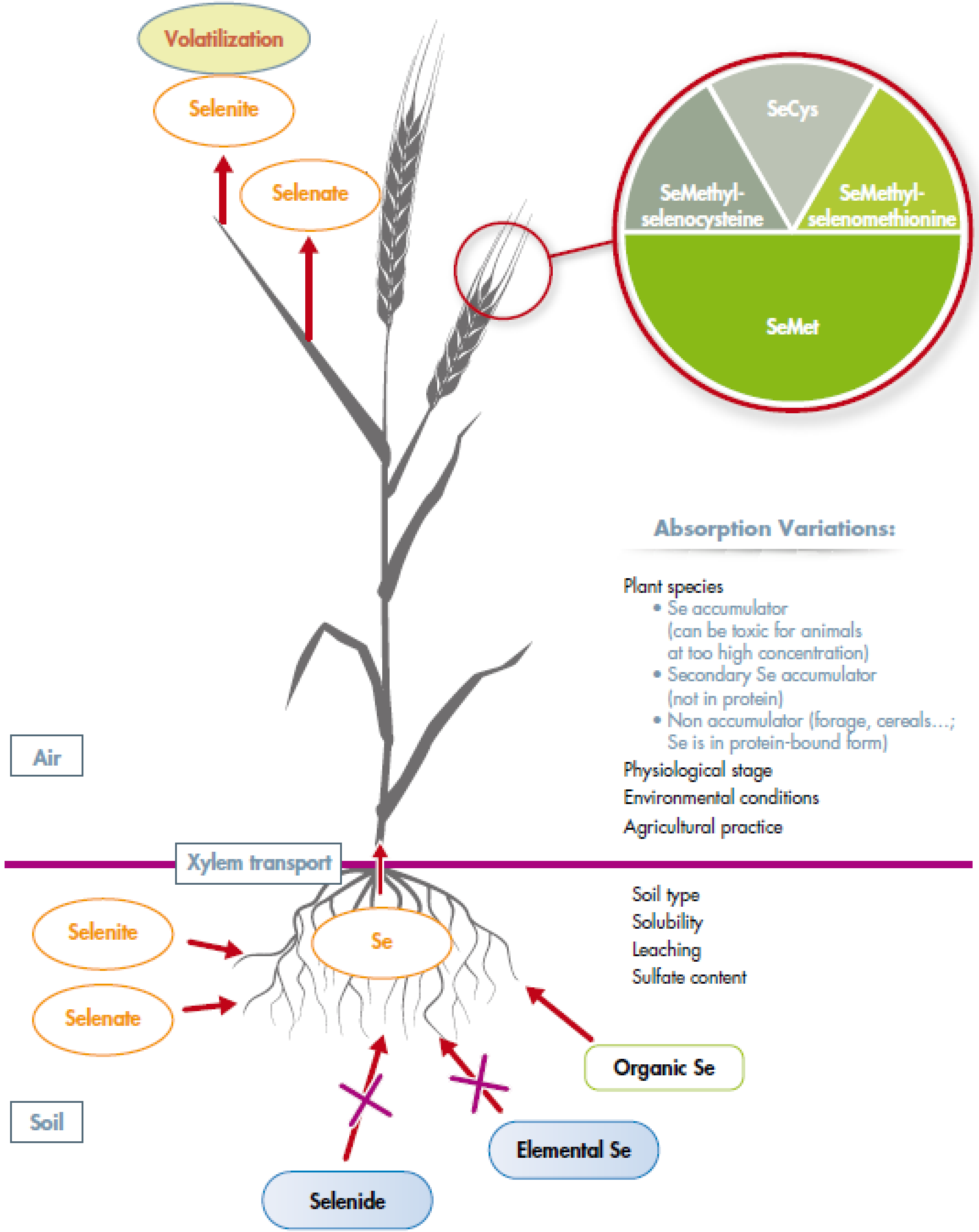


Sodium Selenate



Sodium Selenite

pH↓ absorption↓



Plants differ markedly in their ability to incorporate selenium from soil into tissues; and based on this ability, plants are divided into three major categories:

1. **Selenium accumulators**

   Astragalus, Stanleya, Morinda, Neptunia, Oonopsis,and Xylorhiza

2. **Secondary Se accumulators**

   Aster, Astragalus, Atriplex, Castilleja, Comandra, Grayia, Grindelia, Gutierrezia, Machaeranthera and Brassica

3. **Non-accumulator plants**

   forage, cereal, oilmeal and crop plants

Selenium concentrations in various feed ingredients, mg/kg

Ingredient	USA	Canada
Alfalfa meal	0.01-2.00	0.02-0.27
Barley	0.05-0.5	0.02-0.99
Brewer's grains	0.15-1.00	0.29-1.10
Corn	0.01-1.00	0.01-0.33
Fish meal	1.0-5.0	1.3-3.4
Linseed meal	0.5-1.2	0.7-1.5
Meat meal	0.08-0.5	0.2-0.81
Oats	0.01-1.00	0.01-1.10
Poultry by-product	0.5-0.10	-
Soybean meal	0.06-1.00	0.04-0.78
Wheat	0.1-3.00	0.02-1.5
Wheat bran	0.1-3.0	0.24-1.3
Wheat middling	0.15-1.0	0.41-0.89
Whole soybeans	0.07-0.90	-

Bioavailability of Se in feedstuffs (adapted from Cantor, 1997).

Feedstuff	Biological availability, %
Dehydrated alfalfa meal	210
Brewer's yeast	89
Cottonseed meal	86
Corn	86
Brewer's grains	80
Wheat	71
Distiller's dried grains and solubles	65
Soybean meal	60
Herring meal	25
Tuna meal	22
Poultry by-product meal	18
Menhaden fish meal	16
Meat and bone meal	15
Fish solubles	9

SeMet in grains.

	Grains	SeMet proportion, % total Se	References
Wheat	wheat grain	56-83	Whanger, 2002
	wheat	50.4-81.4	Yang *et al.*, 1997
	wheat grain	72-85	Cubadda *et al.*, 2010
	spring wheat grains, Australia	90	Stadlober *et al.*, 2001
	spring wheat grain, India	66	Cubadda *et al.*, 2010
	durum wheat, Austria	62	Stadlober *et al.*, 2001
	winter wheat grain, India	58	Cubadda *et al.*, 2010
	wheat flour, Belgium	52	Moreno *et al.*, 2004
Barley	summer barley grains, Austria	77	Stadlober *et al.*, 2001
Maize	maize	61-64	Whanger, 2002
	maize	45.5-82.0	Yang *et al.*, 1997
Soybeans	soybeans	>80	Whanger, 2002
	soybeans	62.9-71.8	Yang *et al.*, 1997
Rice	rice	68-81	Whanger, 2002
	rice	54.9-86.5	Yang *et al.*, 1997
	basmati rice, India	93	Mar *et al.*, 2009
	jasmine rice, Thailand	96	Mar *et al.*, 2009
	white rice, USA	94	Mar *et al.*, 2009

Major differences

	Organic selenium	Selenite
Absorption	similar to methionine with active transport in the gut	similar to other mineral with passive transport in the gut
Accumulation	building Se reserves by non-specific incorporation of SeMet into the proteins	not accumulated in the body
Toxicity	at least 3 times less toxic than selenite	highly toxic, can penetrate via skin causing problems
Bioavailability	higher bioavailability in comparison to selenite to animals/poultry	lower bioavailability in comparison to SeMet
Antioxidant activity	possesses antioxidant properties per se and could scavenge NO and other radicals	possesses prooxidant properties and could stimulate free radical production when reacting with GSH
Effect on DNA	stimulate DNA-repair enzymes	causes DNA damage
Transfer to eggs and muscles	transferred to egg and muscles giving an opportunity to produce Se-eggs and Se-meat	poorly transferred to eggs and muscles
Reactions with other elements	neutral, ascorbic acid promotes SeMet assimilation from the diet	highly reactive, reduced to metallic, unavailable selenium by ascorbic acid
Protective effect in stress conditions	provide additional protection due to Se reserves in the body	cannot provide additional protection due to absence Se reserves in the body
Effect on drip loss	decrease drip loss	does not affect drip loss
Environmental issues	better retention in tissues, less released with faeces and urine	low retention in tissues and high release with faeces and urine
Stability	stable	stable
Classification based on the mode of action	feed additive	drug

Functions

Selenium acid > selenite > selenate > selenocysteine > methylated selenium compounds

Molecular mode of action of toxic interaction

- Toxicity occurs from a flaw in protein synthesis.

- Recall that sulfur is a key component of proteins.
  - Sulfur disulfide bonds required for proper folding of protein (tertiary structure)
  - Disulfide bonds are between strands of amino acids
  - Structure=Function

Cells do not discriminate well between Se and Sulfur during protein synthesis
Formation of triselenium linkage (SE-SE-SE) or a selenotrisulfide linkage (S-Se-S)

Functions

- Selenium dependent enzymes
  - Glutathione peroxidase
  - Deiodinases
- Other functions
  - Immune response
  - Complex with heavy metals (Cd, Hg & Ag)

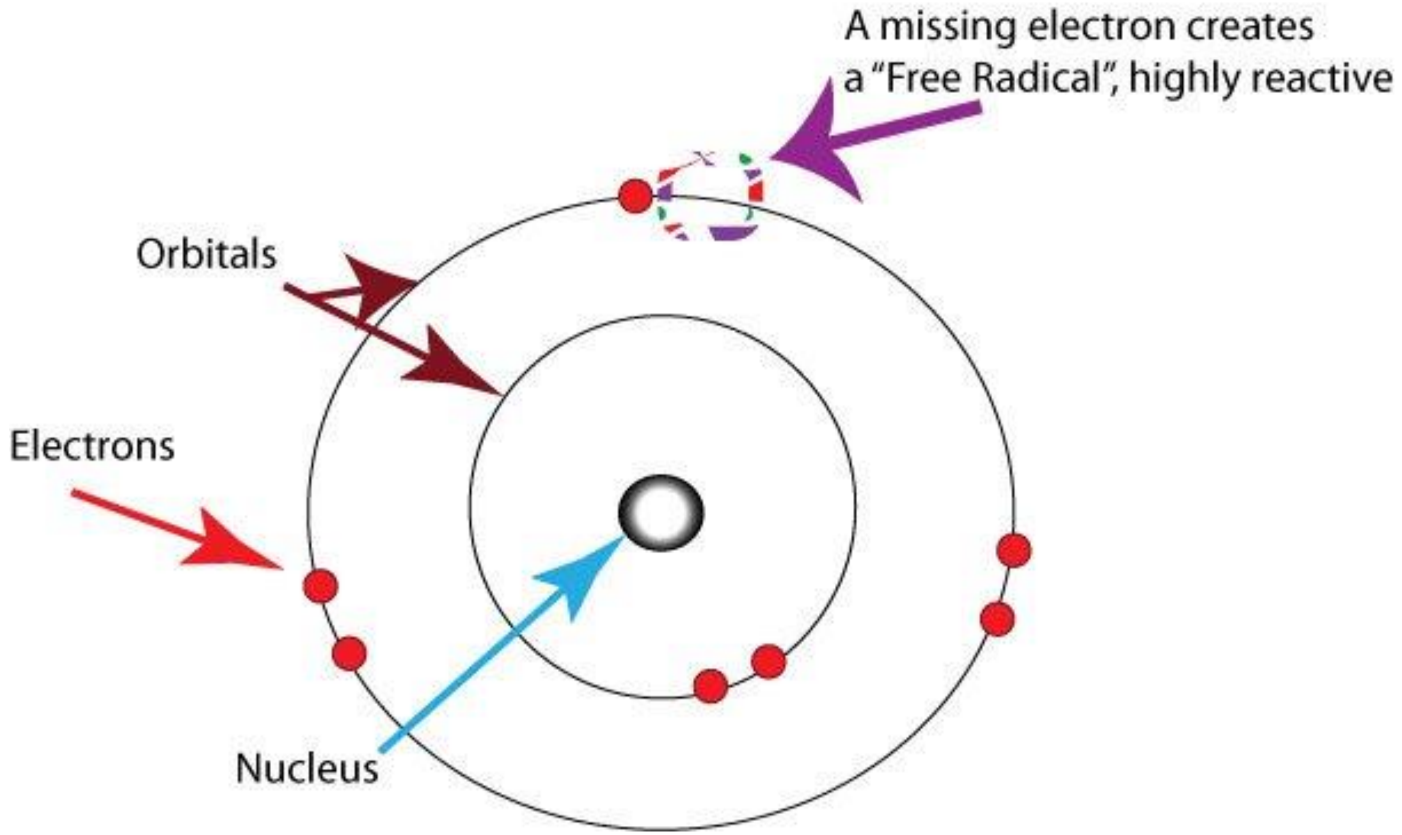
Functions

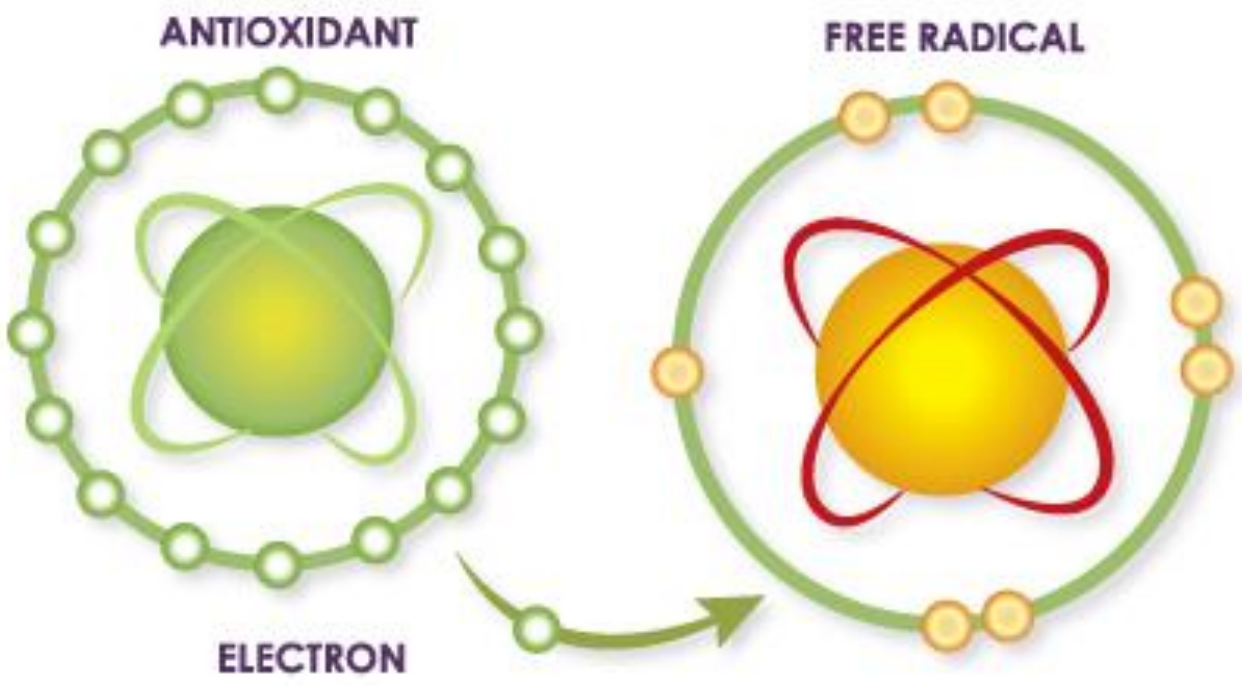
Self-preservation is the first law of nature

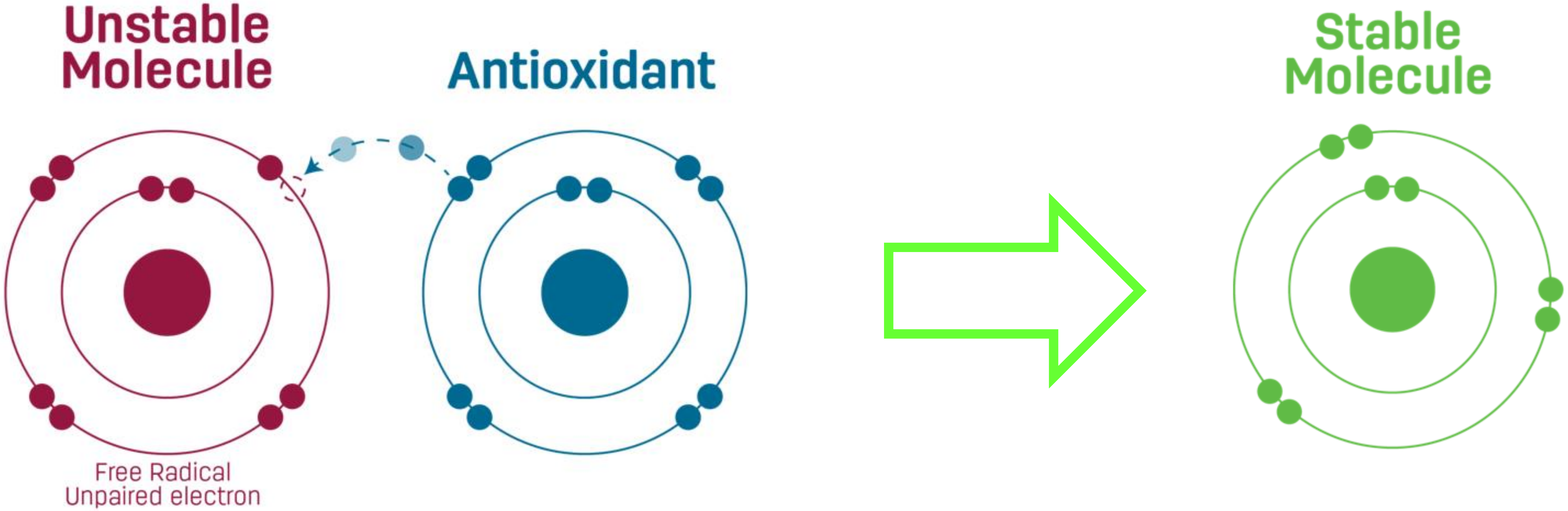
$$LH \xrightarrow{\text{Initiator}} L\bullet$$

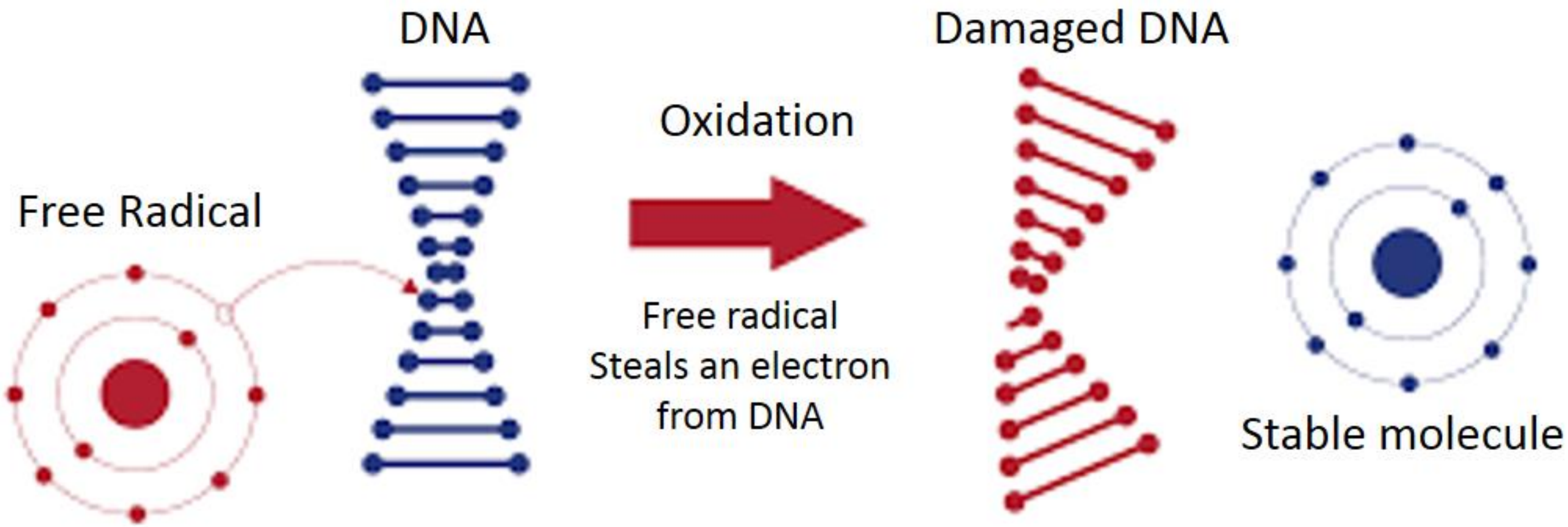
$$L\bullet + O_2 \longrightarrow LOO\bullet$$

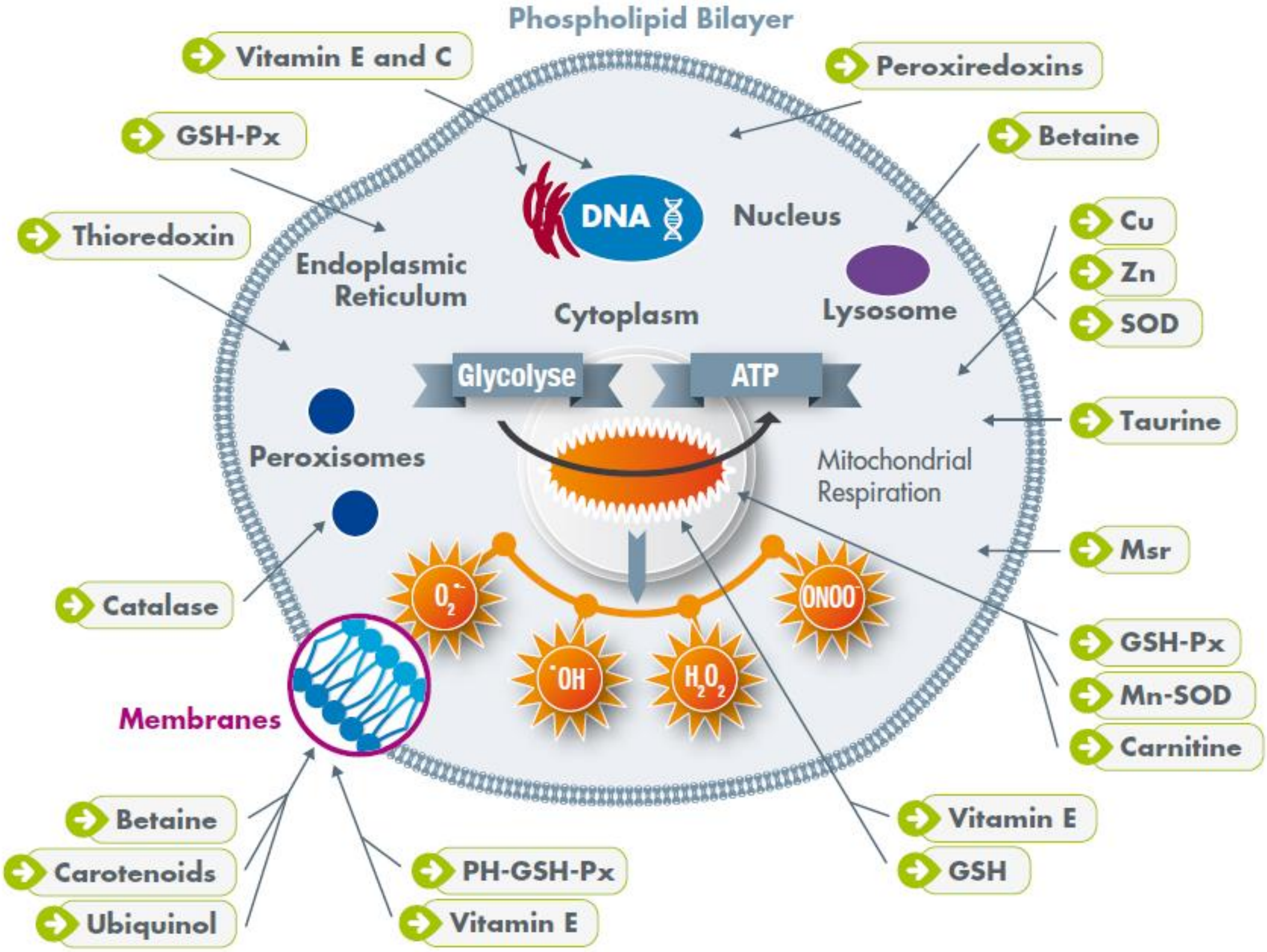
$$LOO\bullet + LH \longrightarrow LOOH + L\bullet$$

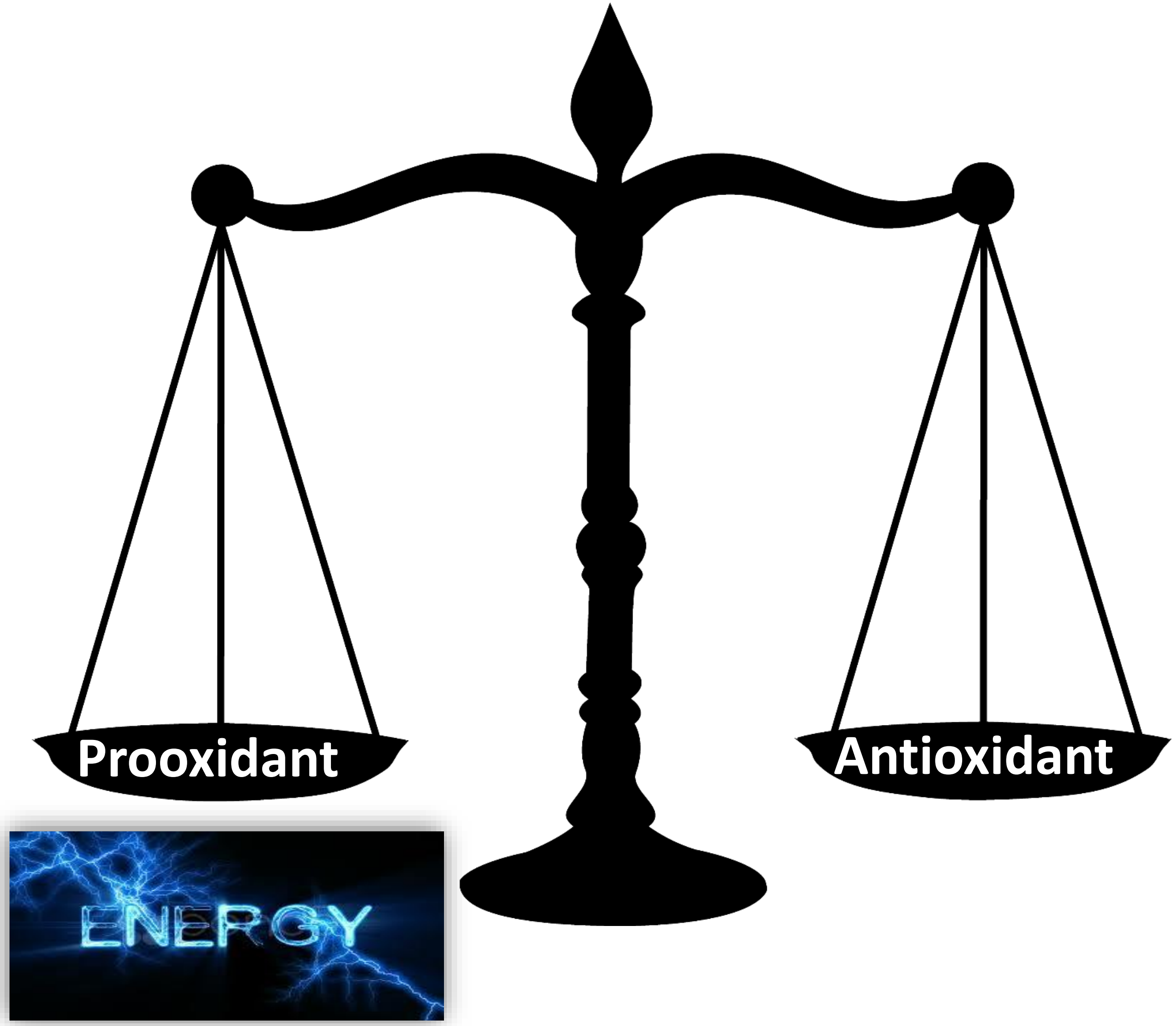

A missing electron creates
a "Free Radical", highly reactive
Orbitals
Electrons
Nucleus

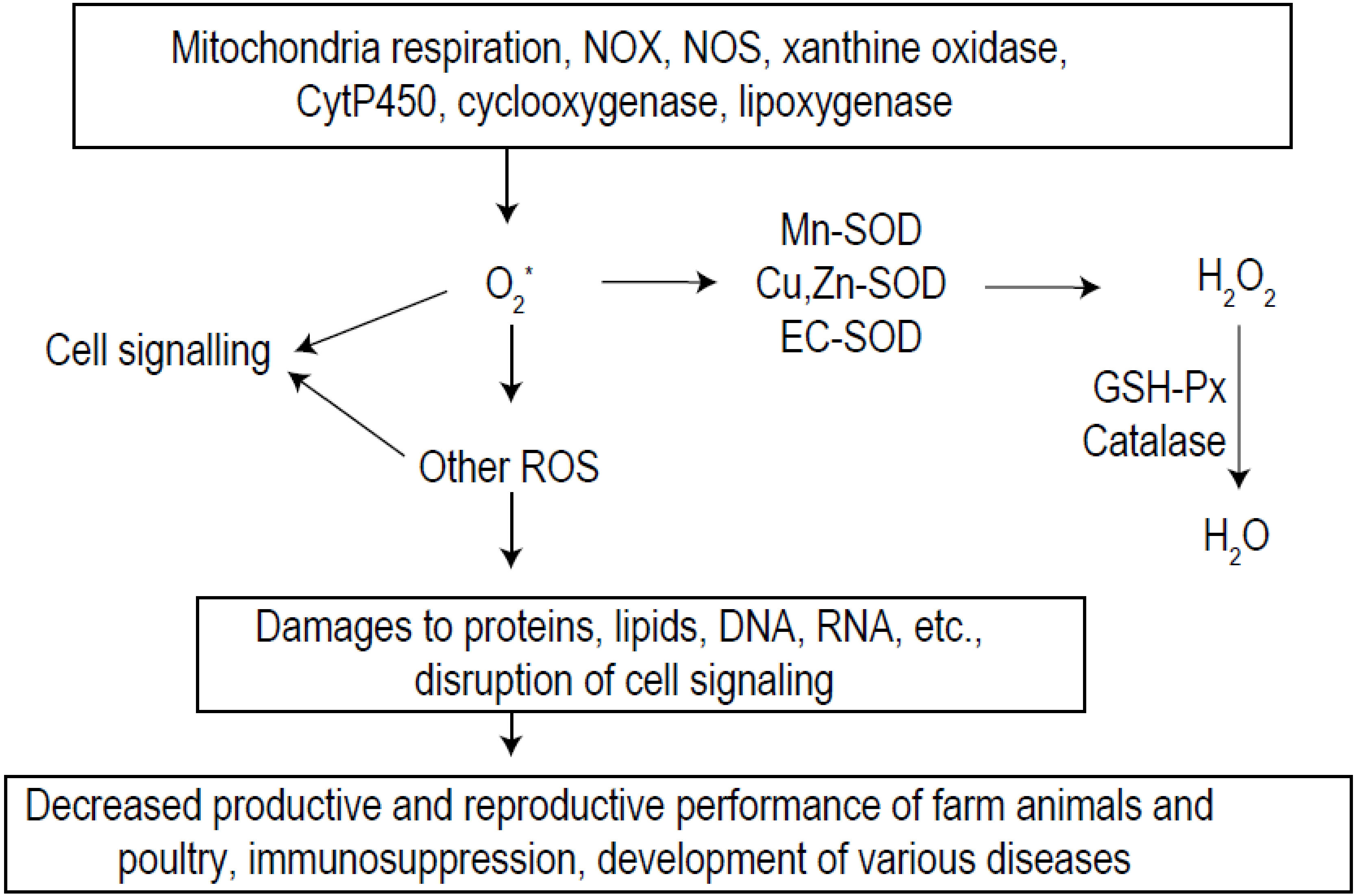

ANTIOXIDANT
FREE RADICAL
ELECTRON


Unstable Molecule
Antioxidant
Stable Molecule
Free Radical
Unpaired electron


DNA
Damaged DNA
Oxidation
Free Radical
Free radical
Steals an electron
from DNA
Stable molecule


Phospholipid Bilayer
Vitamin E and C
Peroxiredoxins
GSH-Px
Betaine
Thioredoxin
DNA
Nucleus
Cu
Zn
SOD
Endoplasmic Reticulum
Cytoplasm
Lysosome
Glycolyse
ATP
Taurine
Peroxisomes
Mitochondrial Respiration
Msr
Catalase
$O_2^{\bullet-}$
ONOO$^-$
$^\bullet$OH$^-$
H_2O_2
GSH-Px
Mn-SOD
Membranes
Carnitine
Betaine
Carotenoids
Ubiquinol
PH-GSH-Px
Vitamin E
Vitamin E
GSH

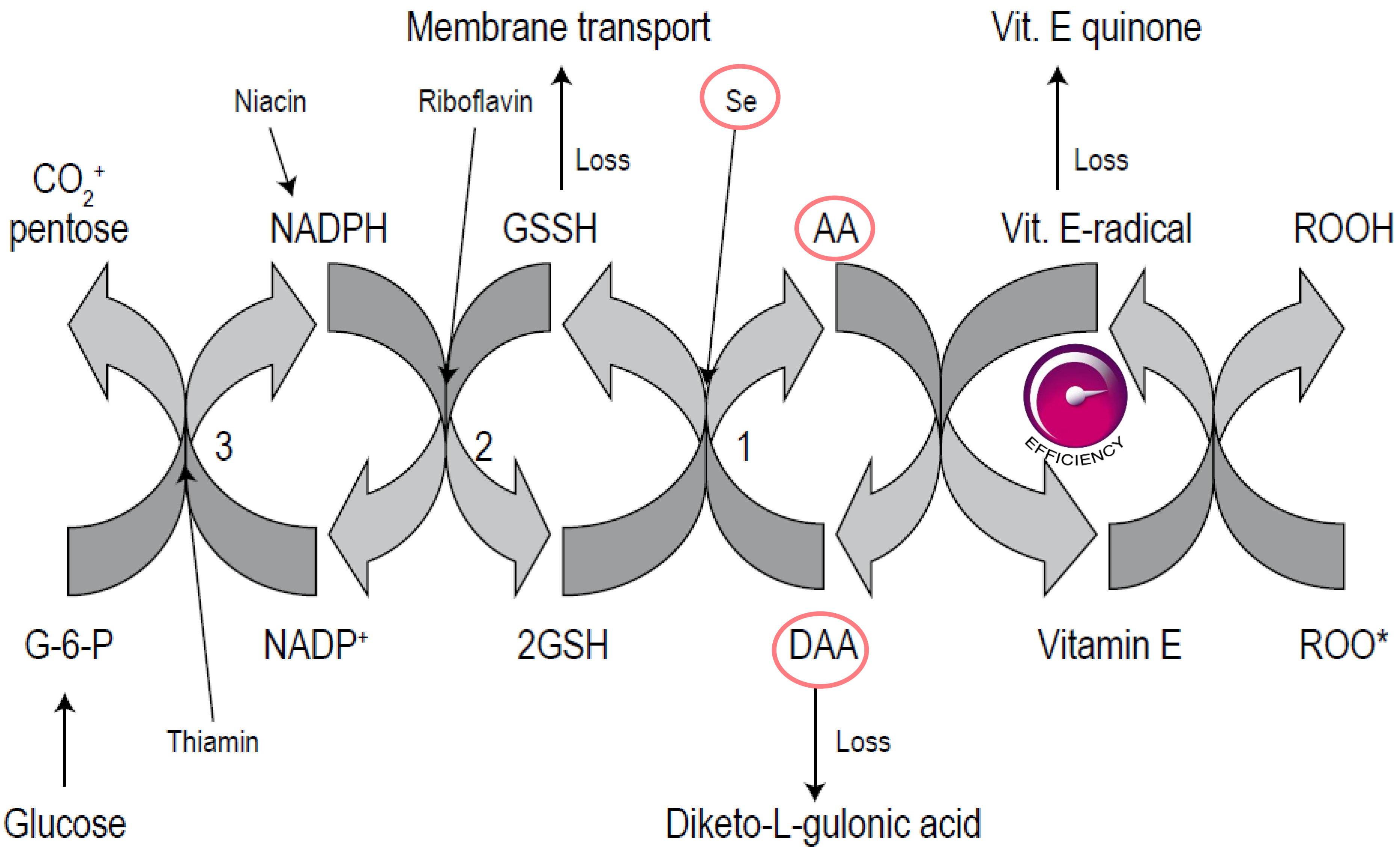

Prooxidant
Antioxidant
ENERGY



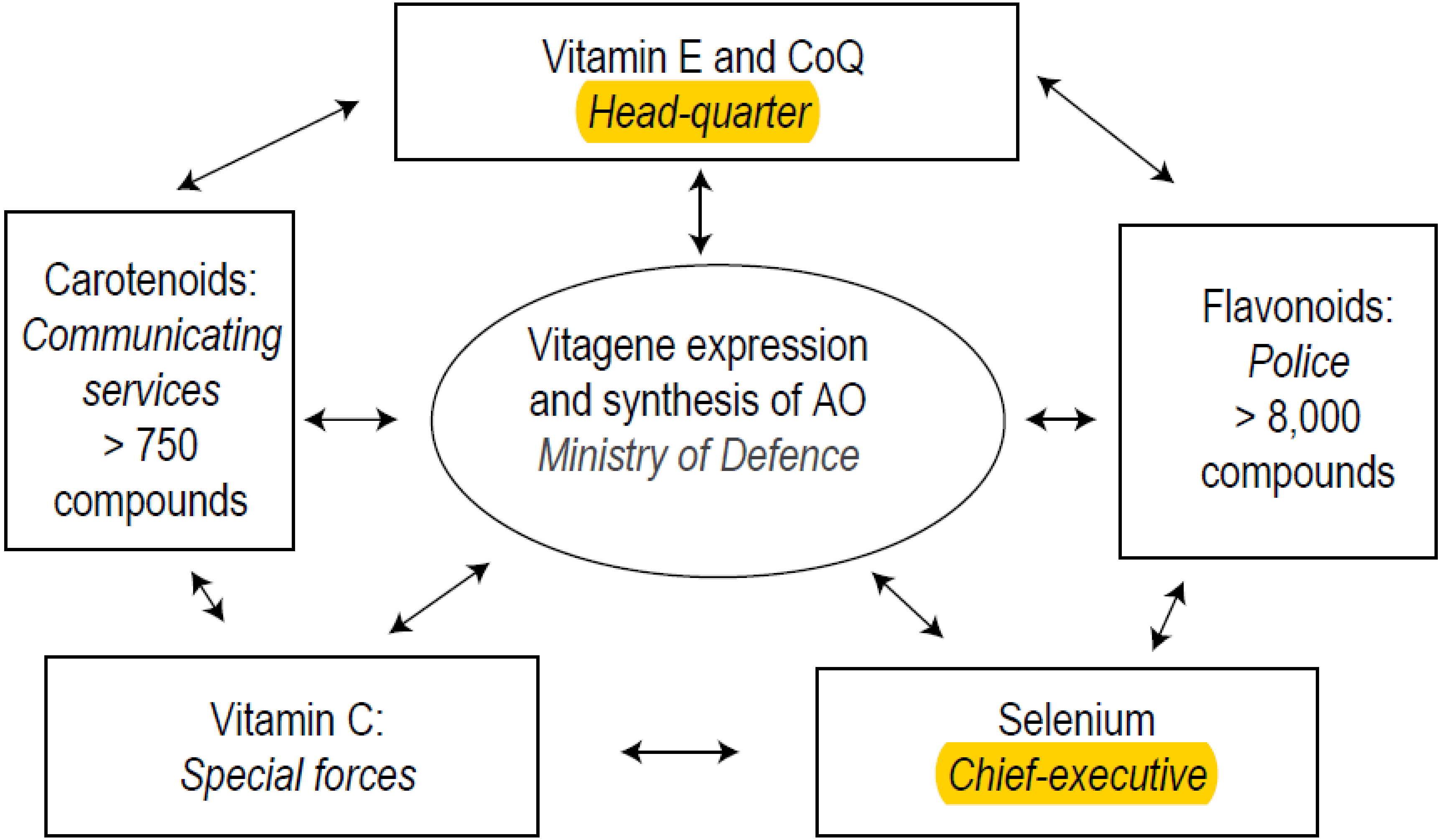
Mitochondria respiration, NOX, NOS, xanthine oxidase, CytP450, cyclooxygenase, lipoxygenase
O_2^*
Mn-SOD
Cu,Zn-SOD
EC-SOD
H_2O_2
Cell signalling
GSH-Px
Catalase
Other ROS
H_2O
Damages to proteins, lipids, DNA, RNA, etc., disruption of cell signaling
Decreased productive and reproductive performance of farm animals and poultry, immunosuppression, development of various diseases

$$LOO\bullet + Toc \longrightarrow Toc\bullet + LOOH$$

$$ROOH + 2GSH \xrightarrow{GSH\text{-}Px} ROH\ (\text{non-toxic}) + H_2O + GSSG$$

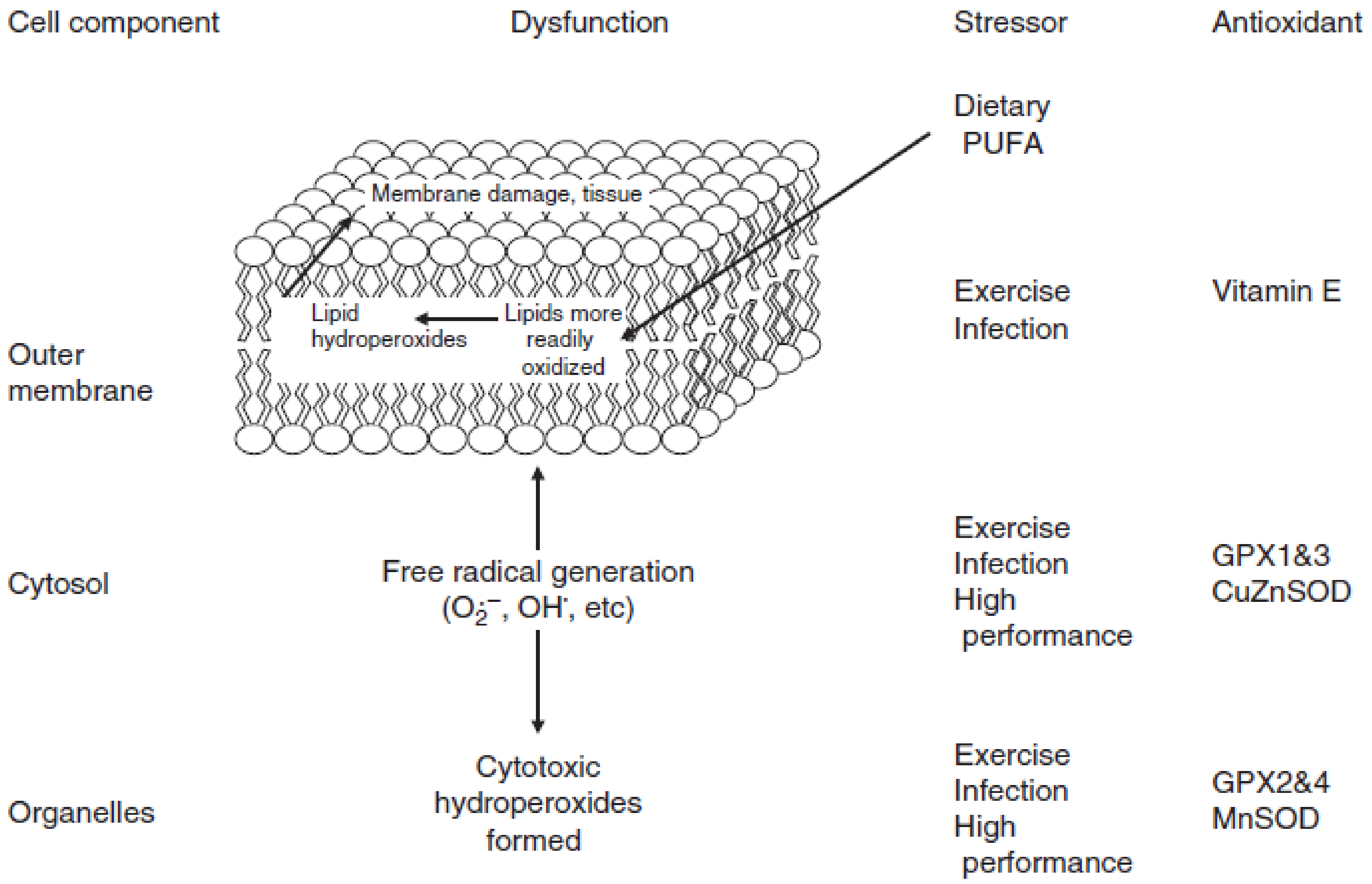


Membrane transport
Vit. E quinone
Niacin
Riboflavin
Loss
Se
Loss
CO_2^+
pentose
NADPH
GSSH
AA
Vit. E-radical
ROOH
3
2
1
EFFICIENCY
G-6-P
NADP+
2GSH
DAA
Vitamin E
ROO*
Thiamin
Loss
Glucose
Diketo-L-gulonic acid


Vitamin E and CoQ
Head-quarter
Carotenoids:
Communicating services
> 750 compounds
Vitagene expression and synthesis of AO
Ministry of Defence
Flavonoids:
Police
> 8,000 compounds
Vitamin C:
Special forces
Selenium
Chief-executive

Selenoproteins that have been purified and/or cloned, their location and possible functions (after Beckett and Arthur, 2005).

Nomenclature	Selenoprotein	Principal location	Function
GPX1	Cytosolic glutathione peroxidases (GPX)	Tissue cytosol, red blood cells	Storage, antioxidant
GPX2	Phospholipid hyperoxide GPX	Intracellular membranes, particularly testes	Intracellular antioxidant
GPX3	Plasma GPX	Plasma, kidney, lung	Extracellular antioxidant
GPX4	Gastrointestinal GPX	Intestinal mucosa	Mucosal antioxidant
GPX5	Epididymal GPX	Epididymis	Weak antioxidant
SPS-2	Selenophosphate synthetase 2	Ubiquitous	SeCys biosynthesis
ID1 or ORD1	Iodothyronine 5′-deiodinase type I	Liver, kidney, muscle[a]	Conversion of T4 to T3
ID2 or ORD2	Iodothyronine 5′-deiodinase type II	BAT	Conversion of T4 to T3
ID3 or ORD3	Iodothyronine 5′-deiodinase type III	Placenta	Conversion of T4 to rT3
TR1 and 2	Thioredoxin reductase 1 and 2	Kidney, brain	Redox cycling
SePN	Selenoprotein N	Muscle	Cell proliferation
SePP	Selenoprotein P	Plasma	Transport, metal detoxifier
SePR	Selenoprotein R	Liver, kidney	Methionine sulfoxide reductase
SePW	Selenoprotein W	Muscle	Antioxidant, calcium-binding
MCSeP	Mitochondrial capsular selenoprotein	Sperm mitochondrial capsule	Store for GPX4


Cell component
Dysfunction
Stressor
Antioxidant
Dietary PUFA
Membrane damage, tissue
Lipid hydroperoxides
Lipids more readily oxidized
Outer membrane
Exercise
Infection
Vitamin E
Cytosol
Free radical generation
(O_2^{-}, $OH^{\cdot}$, etc)
Exercise
Infection
High performance
GPX1&3
CuZnSOD
Organelles
Cytotoxic hydroperoxides formed
Exercise
Infection
High performance
GPX2&4
MnSOD

https://www.ncbi.nlm.nih.gov/pubmed/?term=glutathione+peroxida

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US National Library of Medicine
National Institutes of Health

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Create RSS | Create alert | Advanced | Help

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Clinical Trial
Review
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Text availability
Abstract
Free full text
Full text

Publication dates
5 years
10 years
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Thilakarathna WPDW, Rupasinghe HPV.
Food Chem Toxicol. 2019 Feb 5. pii: S0278-6915(19)30060-2. doi: 10.1016/j.fct.2019.02.010. [Epub ahead of print]
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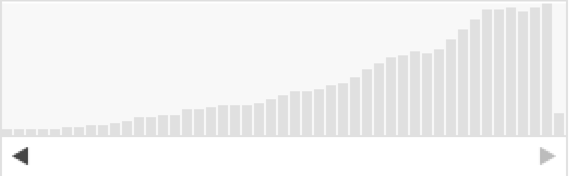

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Abdel-Aziem SH, Abd El-Kader HAM, Ibrahim FM, Sharaf HA, El Makawy AI.
J Genet Eng Biotechnol. **2018** Dec;16(2):653-660. doi: 10.1016/j.jgeb.**2018**.05.001. Epub **2018** Jun 28.
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2. Cadmium-induced hepatocellular injury: Modulatory effects of γ-glutamyl cysteine on the biomarkers of inflammation, DNA damage, and apoptotic cell death.
Salama SA, Arab HH, Hassan MH, Al Robaian MM, Maghrabi IA.
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Li T, Yu H, Song Y, Zhang R, Ge M.
J Trace Elem Med Biol. 2019 Mar;52:118-125. doi: 10.1016/j.jtemb.**2018**.12.010. Epub **2018** Dec 15.
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Characteristics of human selenoproteins

Protein	Protein length	SeCys position	Cellular distribution/tissues/species	Functions
Cytosolic GSH-Px (GSH-Px1)	201	47	cytosol	AO protection
GI-GSH-Px (GSH-Px2)	190	40	gastrointestinal tract	AO protection
pGSH-Px (GSH-Px3)	226	73	extracellular space and plasma	maintenance of cellular redox status
PH-GSH-Px (GSH-Px4)	197	73	cell membrane, many other tissues	detoxification of lipid hydroperoxides
Cytosolic TrxR1 (TrxR1)	499	498	cytosol, liver, kidney, heart	part of the Trx system, AO defence, redox regulation, cell signalling
Mitochondrial TrxR2 (TrxR2)	523	522	mitochondria, liver kidney	part of the Trx system, AO defence, redox regulation, cell signalling
TR3 (testicular) (TGR, TrxR3)	656	655	Testes	part of the Trx system, AO defence, redox regulation, cell signalling
Iodothyronine deiodinase 1 (Dio1)	249	126	many tissues like liver, kidney, thyroid	conversion of T4 to T3 and T4 to reverse T3
Iodothyronine deiodinase 2 (Dio2)	265	133	liver, kidney, thyroid, brown adipose tissue	conversion of T4 to T3
Iodothyronine deiodinase 3 (Dio3)	278	144	placenta, brain, skin, (not in pituitary, thyroid, adult liver)	conversion T4 to reverse T3
Selenoprotein H (SepH, SelH)	122	44	widely distributed	upregulation of genes involved in GSH synthesis
Selenoprotein I (SelI,SepI)	397	387	widely distributed	lipid metabolism
Selenoprotein K (Selke, SepK)	94	92	cardiomyocytes	possible AO protection in cardiomyocytes
Selenoprotein M (SelM, SepM)	145	48	brain and other tissues	distantly related to Sel15.
Selenoprotein N (SelN, SepN)	556	428	endoplasmatic reticulum	it is linked with rigid spine syndrome
Selenoprotein O (SelO, SepO)	669	667	widely distributed	unknown
Selenoprotein P (SepP, SepP1)	381	59 [a]	plasma, other tissues	involved in Se transport, AO defence
Selenoprotein Pb			plasma, other tissues	unknown
Methionine-R-sulfoxide reductase 1a (MsrB1, SelR, SelX)	116	95	cytosol, nucleus	reduction of oxidised methionine residues in damaged proteins
Selenoprotein S (SelS, SepS)	189	188	endoplasmatic reticulum	cellular redox balance, possible influence of inflammatory response
Selenophosphate synthetase 2a (SPS, SPS2, SPS2a)	448	60	testes, many other tissues	synthesis of selenophosphate
Selenoprotein T (SelT, SepT)	182	36	ubiquitous	role in regulation of Ca^{2+} homeostasis and neuroendocrine secretion
Selenoprotein U (SelU, SepU1)			fish and chicken, but not higher eukaryotes	unknown
Selenoprotein W (SelW, SepW1)	87	13	muscle, heart and other tissues	antioxidant protection
15-kDa Selenoprotein (Sel15, Sep15)	162	93	endoplasmatic reticulum	antioxidant protection

[a] All positions of SeCys in SeP: 59, 300, 318, 330, 345, 352 367, 369, 376, 378.

[b] AO = anti-oxidant; GSH = glutathione; TrxR = thioredoxin reductase.

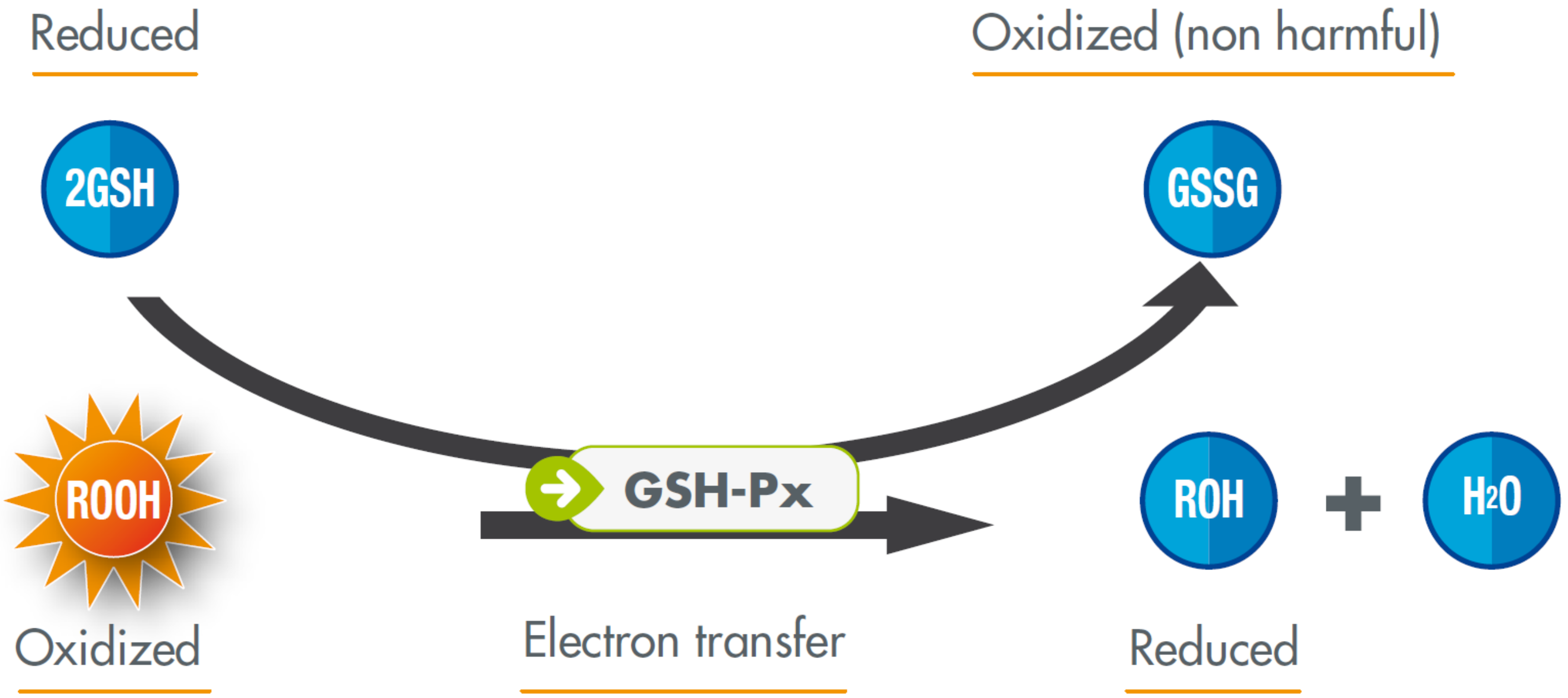
Se-dependent glutathione peroxidase characteristics

Glutathione peroxidase	Nomenclature	Localisation	Subunit size (kDa)	Substrates	Electron donors	Other characteristics
Cytosolic GSH-Px	GSH-Px1	intracellular, cytosolic, partly mitochondria	21.9	H_2O_2, t-BHP	GSH	Erythrocytes, kidney and liver
Gastrointestinal GSH-Px	GSH-Px2	intracellular, cytosolic	21.9	H_2O_2, t-BHP	GSH	mucosal epithelial cells in GIT
Extracellular (plasma) GSH-Px	GSH-Px3	plasma	25.5	H_2O_2, t-BHP, phospholipid hydroperoxides	GSH, thioredoxin, gluta-redoxin	expressed in kidney
Phospholipid hydroperoxide GSH-Px	GSH-Px4	intracellular, partly cytosolic, mitochondrial, membrane-bound	22.1	H_2O_2, phospholipid hydroperoxides	GSH, DTT, 2-ME, L-cys	renal epithelial cells and testes

[1] t-BHP = tret-butylhydroperoxide; DTT = 1,4-ditiothreitol; 2-ME = 2-mercaptoethanol; L-cys = L-cysteine.; GIT = gastrointestinal tract; GSH = glutathione.

Total glutathione peroxidase (GSH-Px) activity in the liver of various animals, U/mg protein

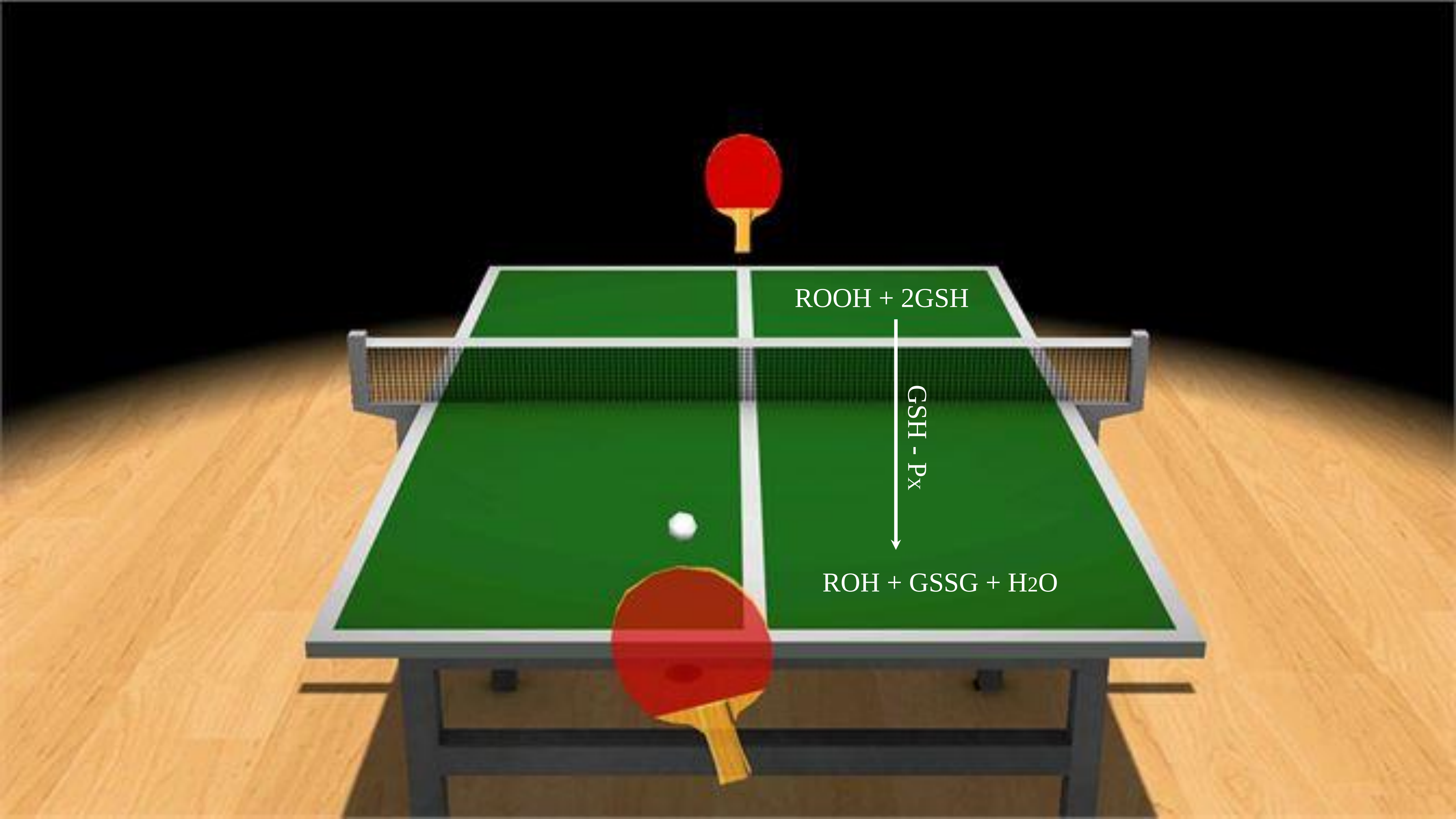
Animal	GSH-Px activity	Animal	GSH-Px activity
Chicken	33	White mouse	468
Cattle	70	Ground squirrel	49
Sheep	64	Cat	67
Rat	245	Dog	20
Mouse	476	Rainbow trout	0.9
Guinea pig	12	Blue gill sunfish	3.4
Hamster	920	Carp	143
Rabbit	496	Fence lizard	22
Gerbil	683	American toad	2
Wild house mice	446	Western newt	1.5

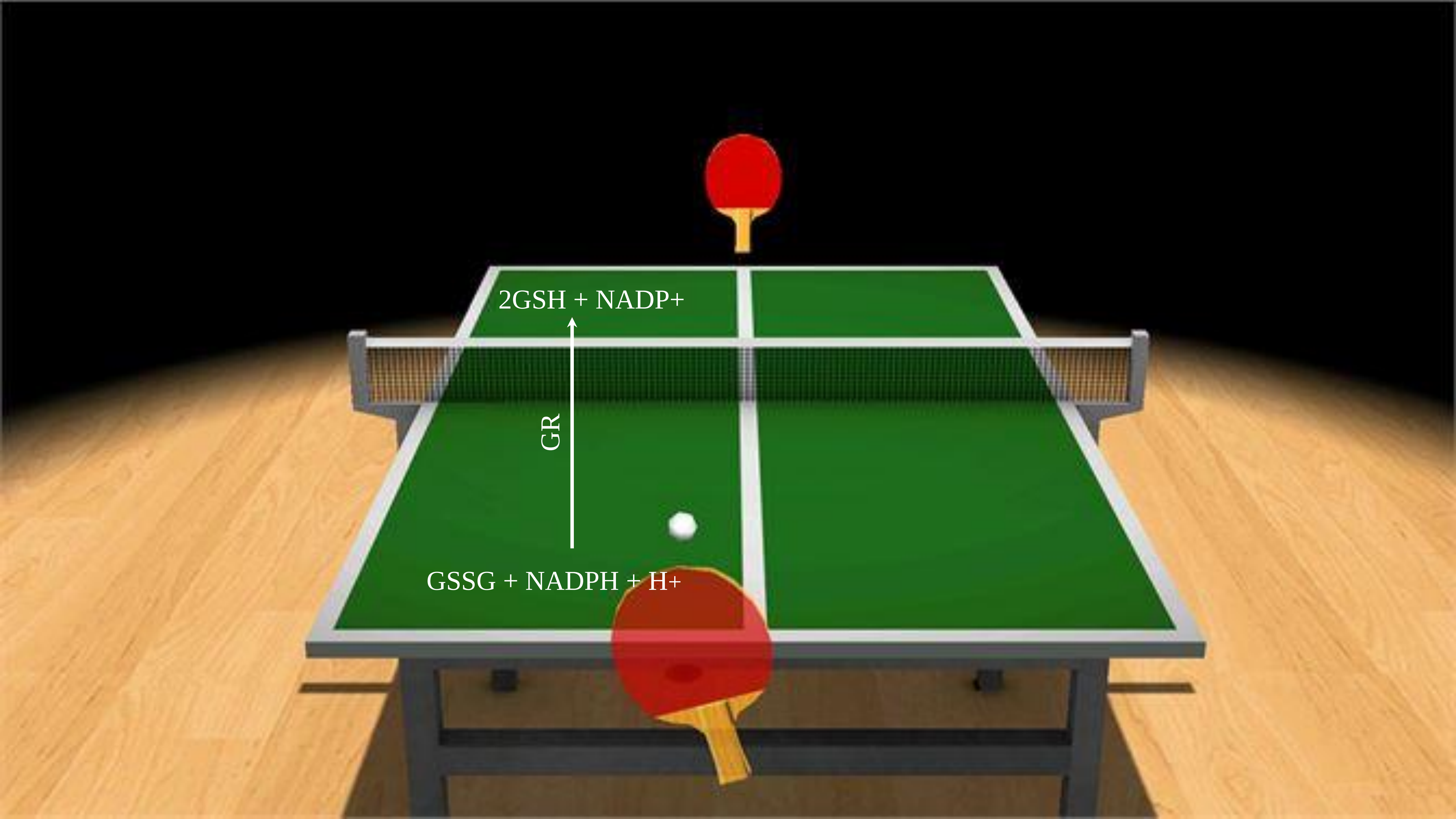

Reduced
Oxidized (non harmful)
2GSH
GSSG
ROOH
GSH-Px
ROH
+
H2O
Oxidized
Electron transfer
Reduced

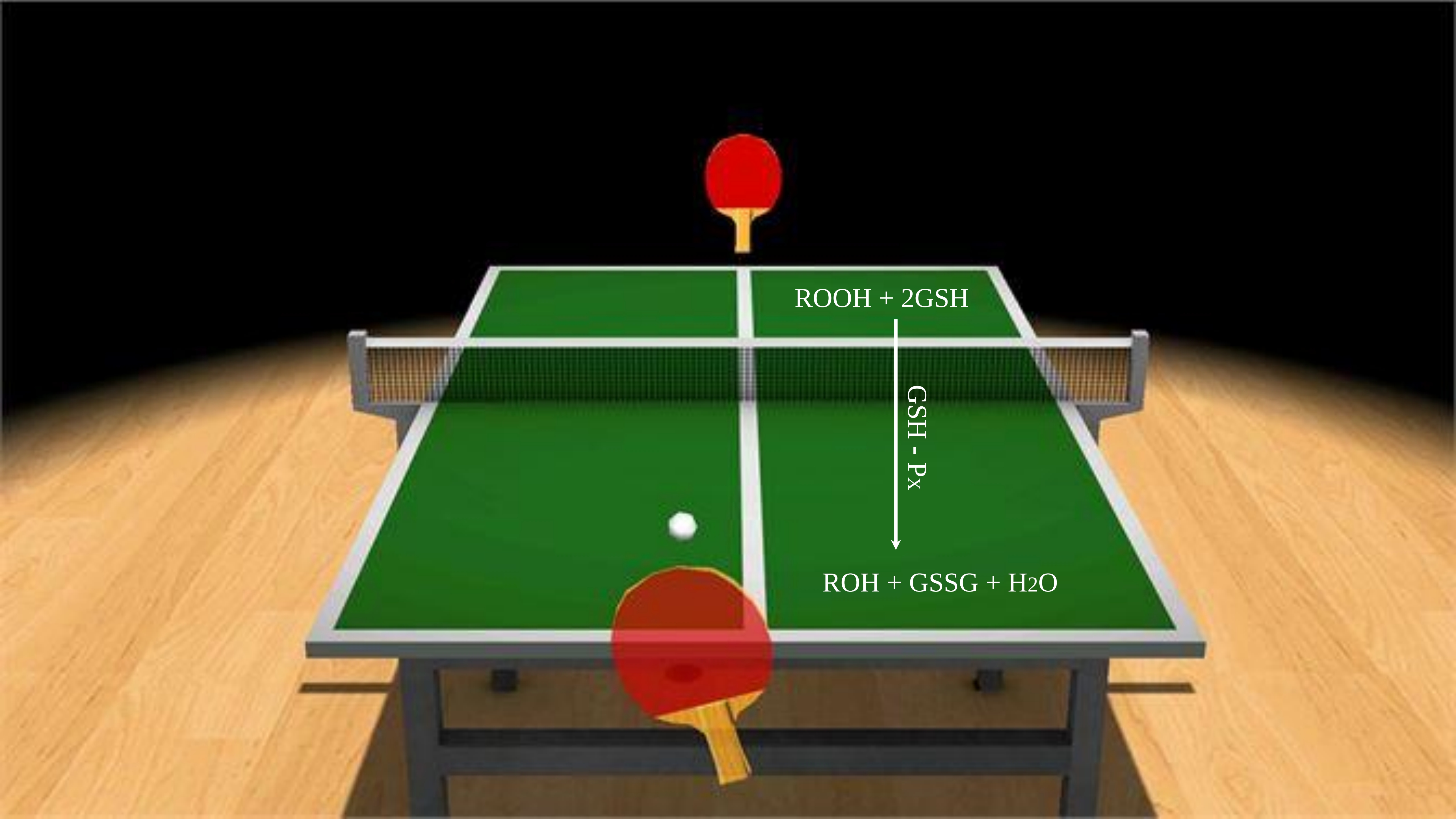
- 4 different GSH-Px in avian species
- Selenium feed supplementation ↗ GSH-Px activity

Different biological roles:

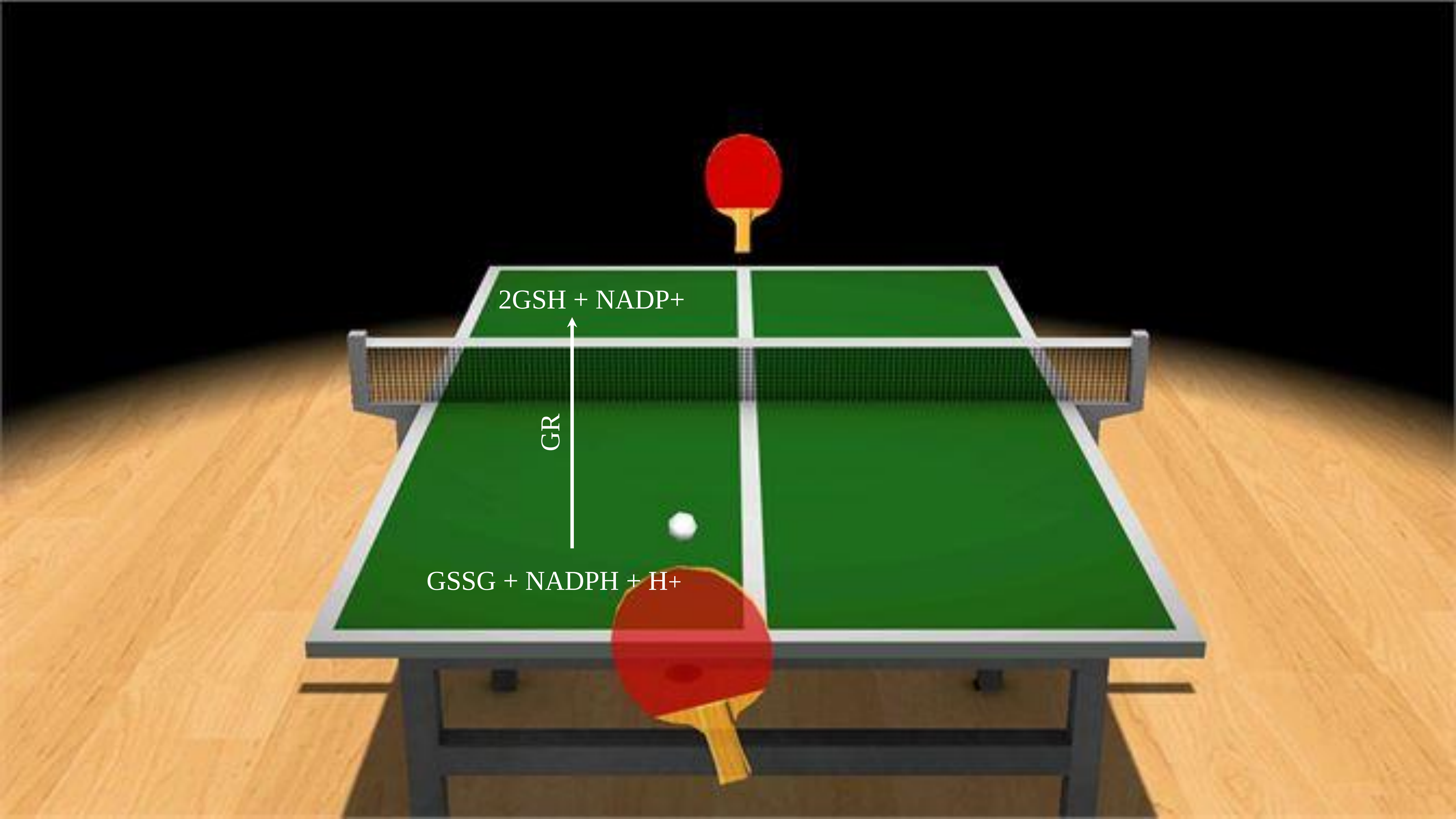
- Prevention of lipid peroxidation
- ROS detoxification
- Specific role of GSH-Px 4 in male fertility

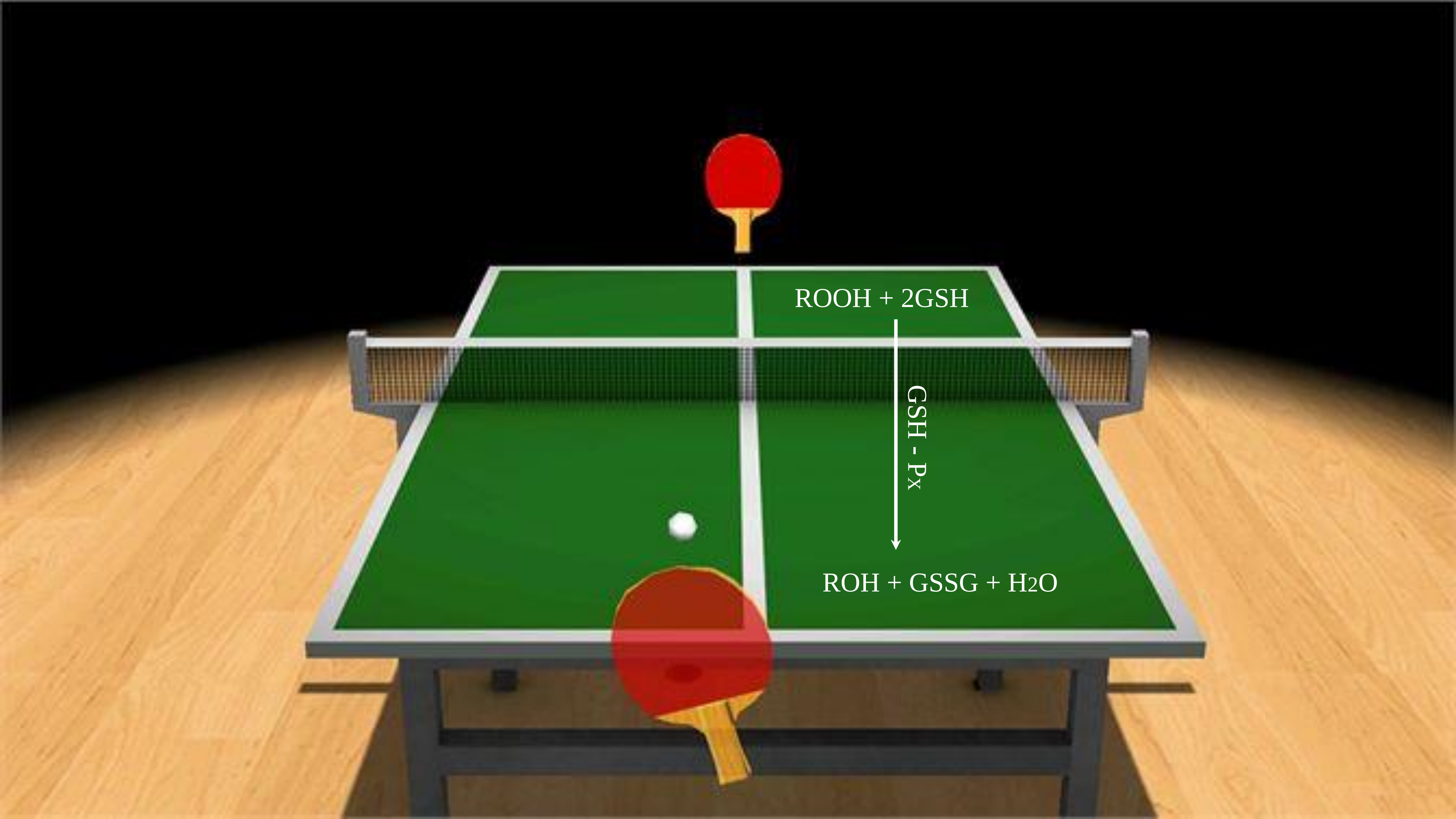

ROOH + 2GSH
GSH - P_x
ROH + GSSG + H_2O


2GSH + NADP+
GR
GSSG + NADPH + H+

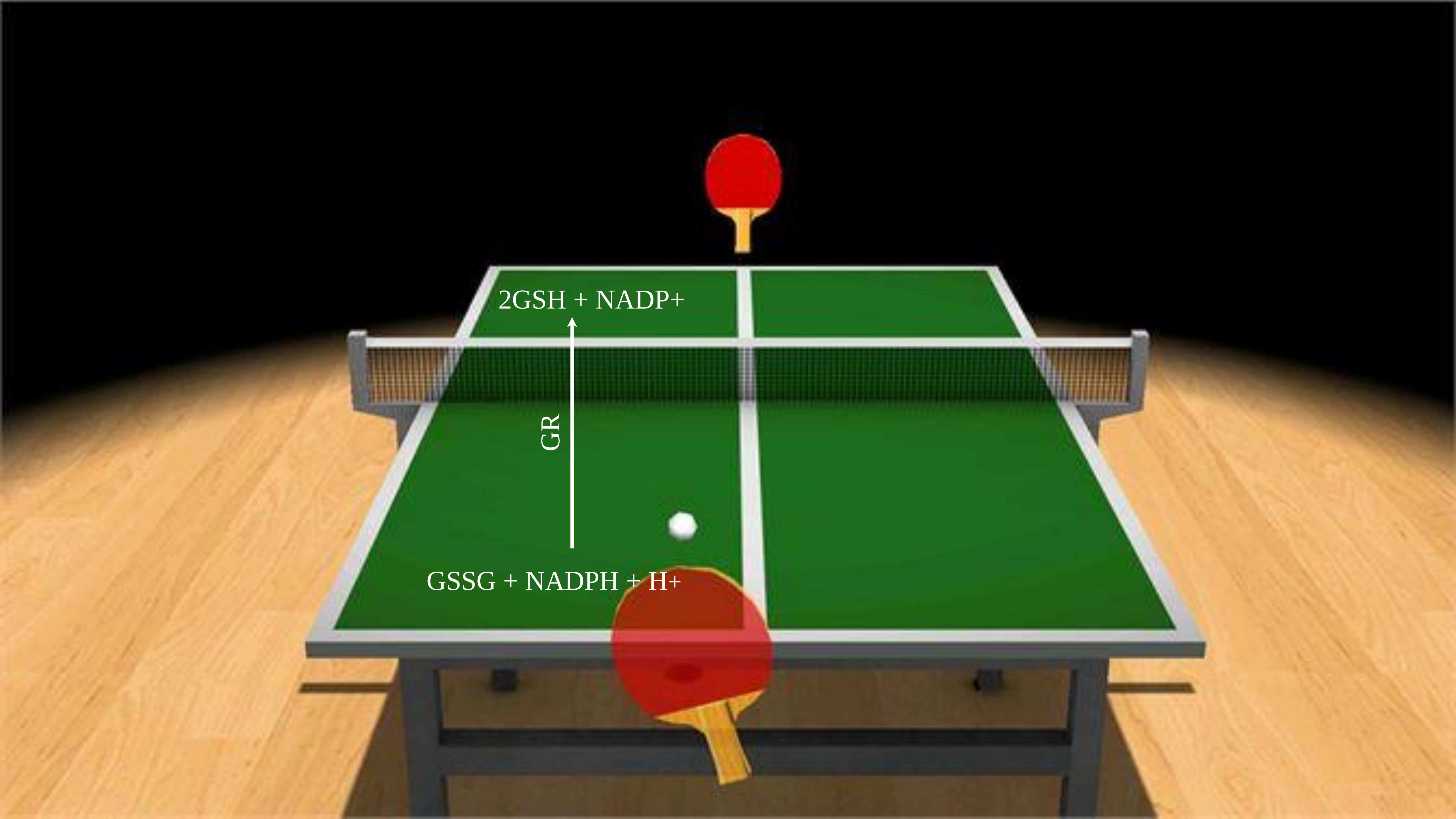


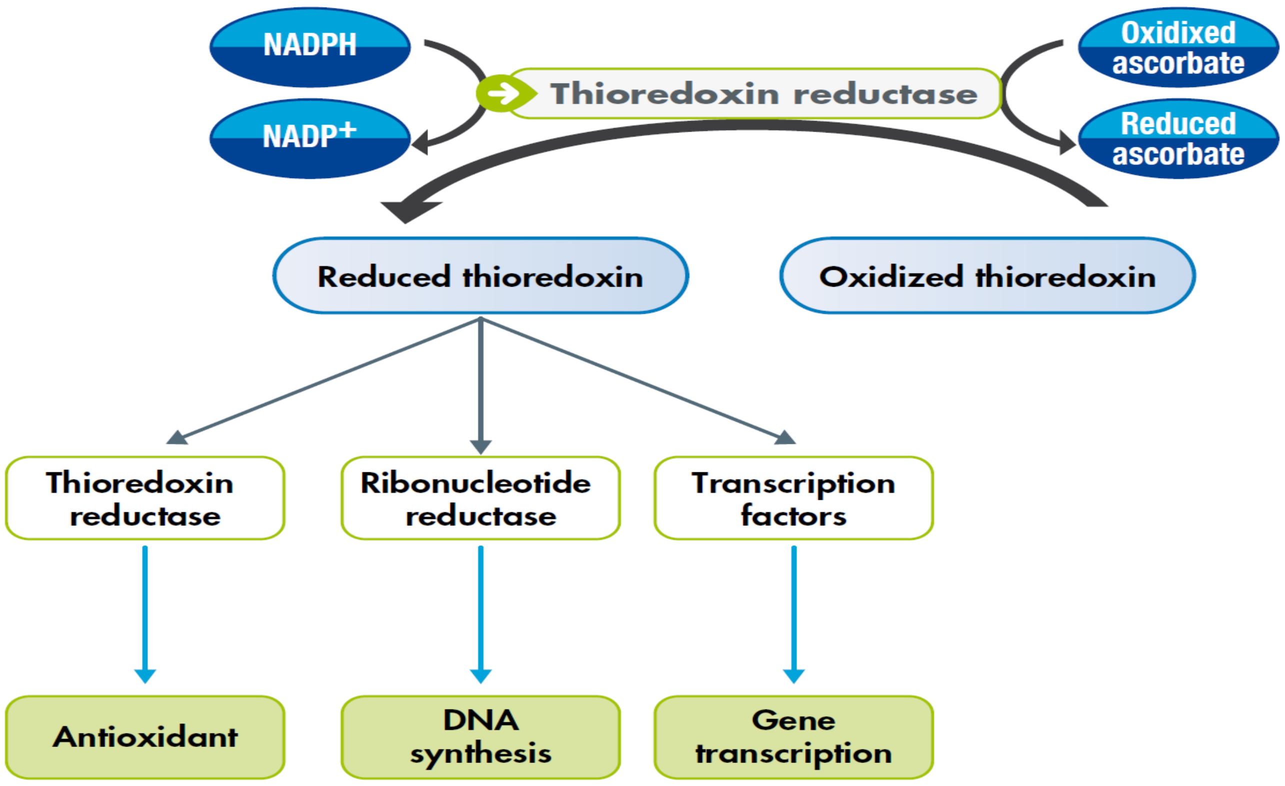
$$ROOH + 2GSH \xrightarrow{GSH\text{-}Px} ROH + GSSG + H_2O$$


2GSH + NADP+
GR
GSSG + NADPH + H+



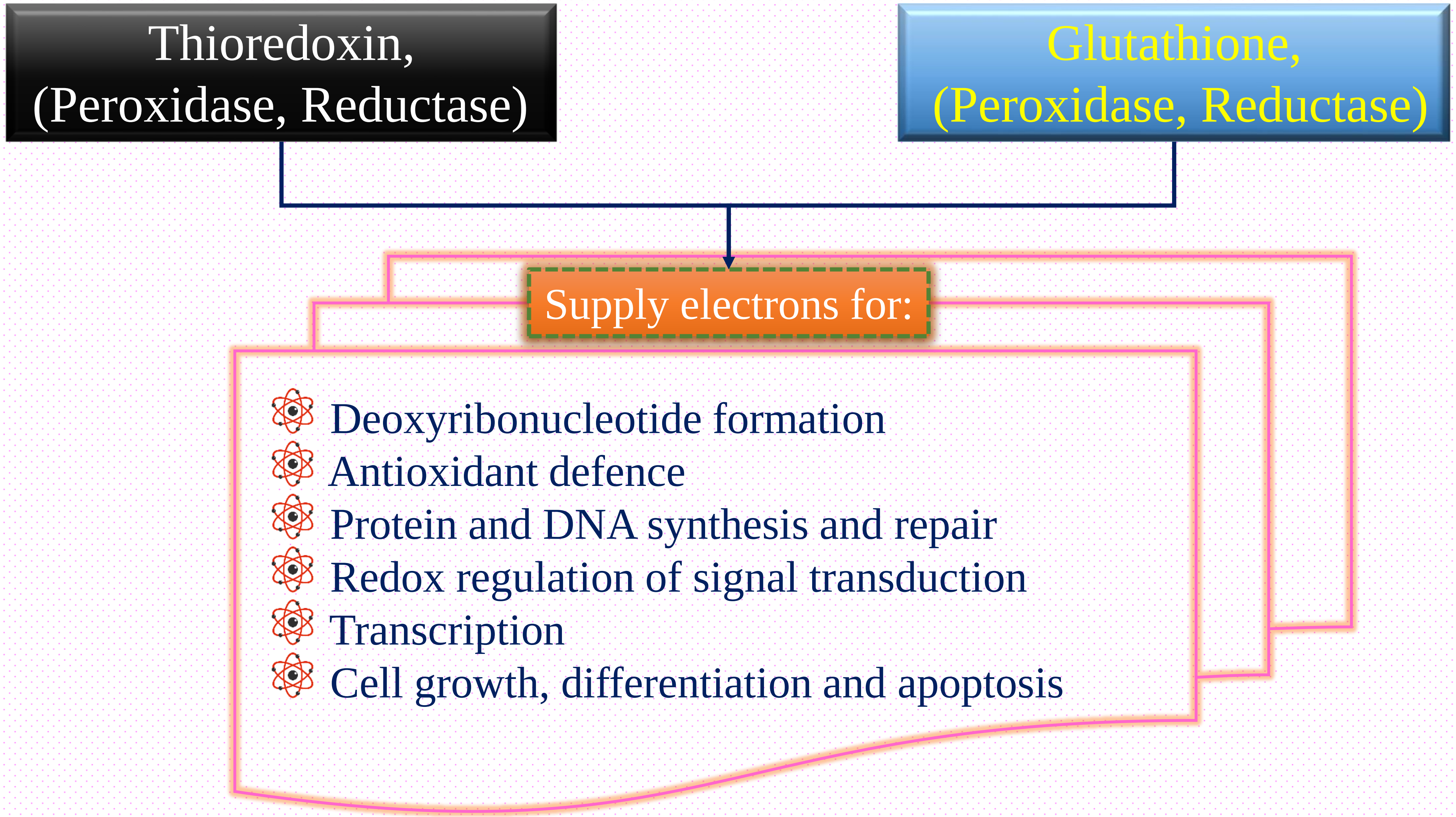
$$ROOH + 2GSH \xrightarrow{GSH-Px} ROH + GSSG + H_2O$$


2GSH + NADP+
GR
GSSG + NADPH + H+



TrxR plays a role in:

- Cell growth
- Inhibition of apoptosis
- Cellular sensitivity to glucocorticoids
- Immunomodulation
- Pregnancy and birth
- Neuronal survival


Thioredoxin,
(Peroxidase, Reductase)
Glutathione,
(Peroxidase, Reductase)
Supply electrons for:
Deoxyribonucleotide formation
Antioxidant defence
Protein and DNA synthesis and repair
Redox regulation of signal transduction
Transcription
Cell growth, differentiation and apoptosis

Other selenoproteins

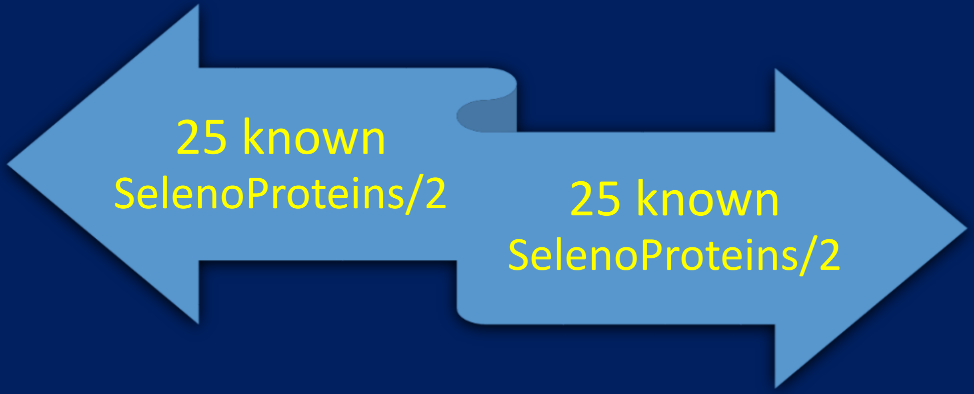
I. Iodothyronine deiodinases
II. Selenophosphate synthetase-2
III. 15-kDa selenoprotein
IV. Selenoprotein H
V. Selenoprotein I
VI. Selenoprotein K
VII. Selenoprotein M
VIII. Selenoprotein N
IX. Selenoprotein O
X. Selenoprotein P
XI. Selenoprotein Pb
XII. Selenoprotein R
XIII. Selenoprotein S
XIV. Selenoprotein T
XV. Selenoprotein U
XVI. Selenoprotein W

Selenoprotein location in chicken

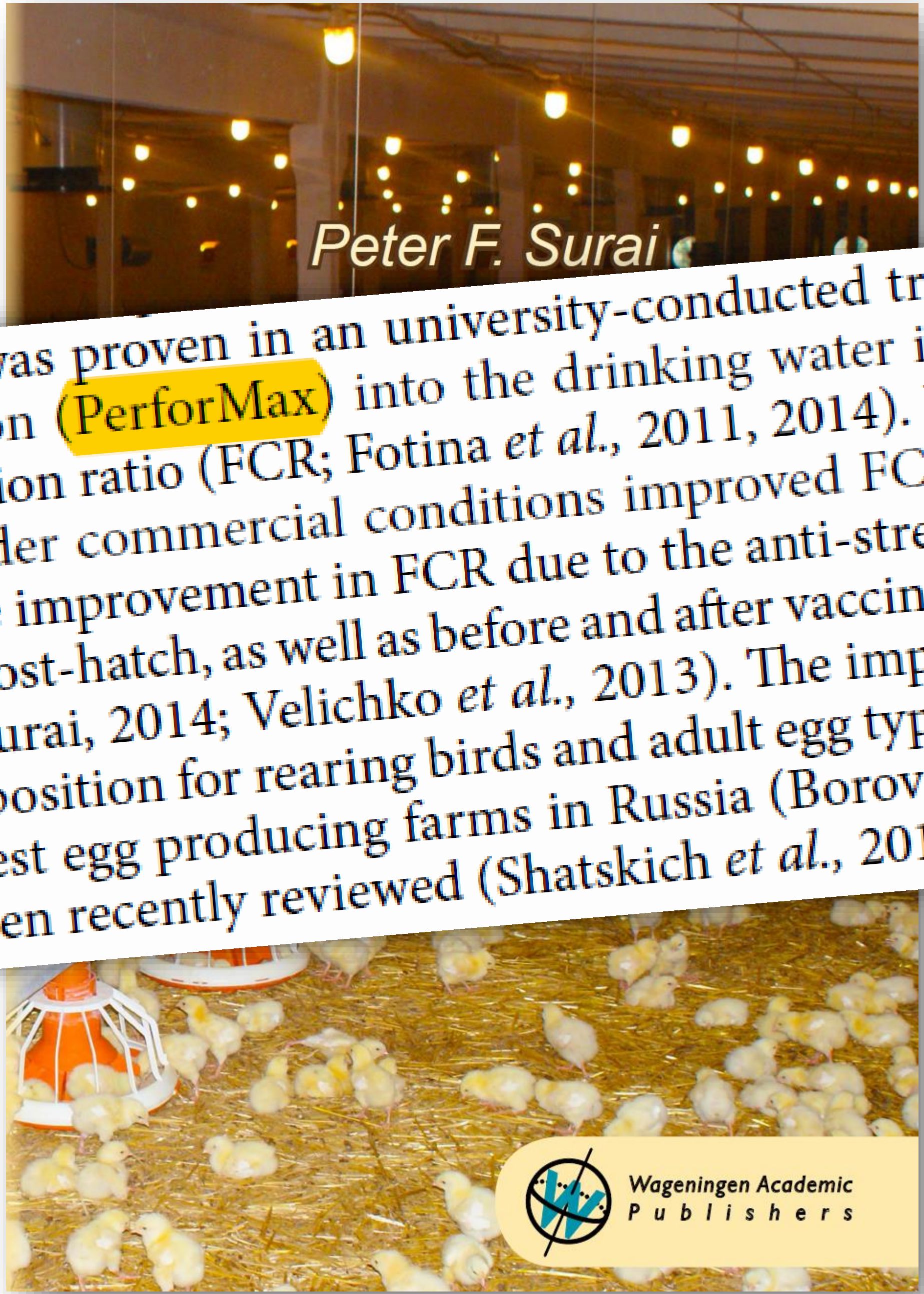
Location/feature	Selenoproteins
Inside the cell	GSH-Px1, GSH-Px2, GSH-Px4, DIO1, DIO2, DIO3, TrxR1, TrxR2, TrxR3, Sep15, SelH, SelI, SelK, SelM, SelN, SelO, SelT, SelU, SelW, MsrB1, SPS2
Outside the cell/secreted	SelPa, SelPb and GSH-Px3
Endoplasmic reticulum	DIO1, DIO2, DIO3, Sep15, SelI, SelK, SelM, SelN SelS and SelT
Mitochondria	GSH-Px1, GSH-Px2, GSH-Px4, TrxR1, TrxR2, TrxR3, SelM, SelO and SelU
Cytoplasm	GSH-Px1, GSH-Px2, GSH-Px4, TrxR1, TrxR2, TrxR3 and SelW
Nucleus	GSH-Px4, MsrB1 and SelH
Golgi apparatus	SelT
Membrane	SelI
Membrane-bound	SelI, SelK, SelS, SelT, DIO1 and DIO3
Zn-containing	Sep15, MsrB1, SelW and SelM
POP-containing	GSH-Px1, GSH-Px2, GSH-Px3 and GSH-Px4
Thioredoxin-like fold-containing	GSH-Px1, GSH-Px2, GSH-Px3, GSH-Px4, DIO1, DIO2, DIO3, TrxR3, SelT, SelH, SelW, Sep15, SelM, SelU and SelO
Flavin adenine dinucleotide-interacting	TrxR1, TrxR2 and TrxR

Vitagene Concept

Antioxidant Defences



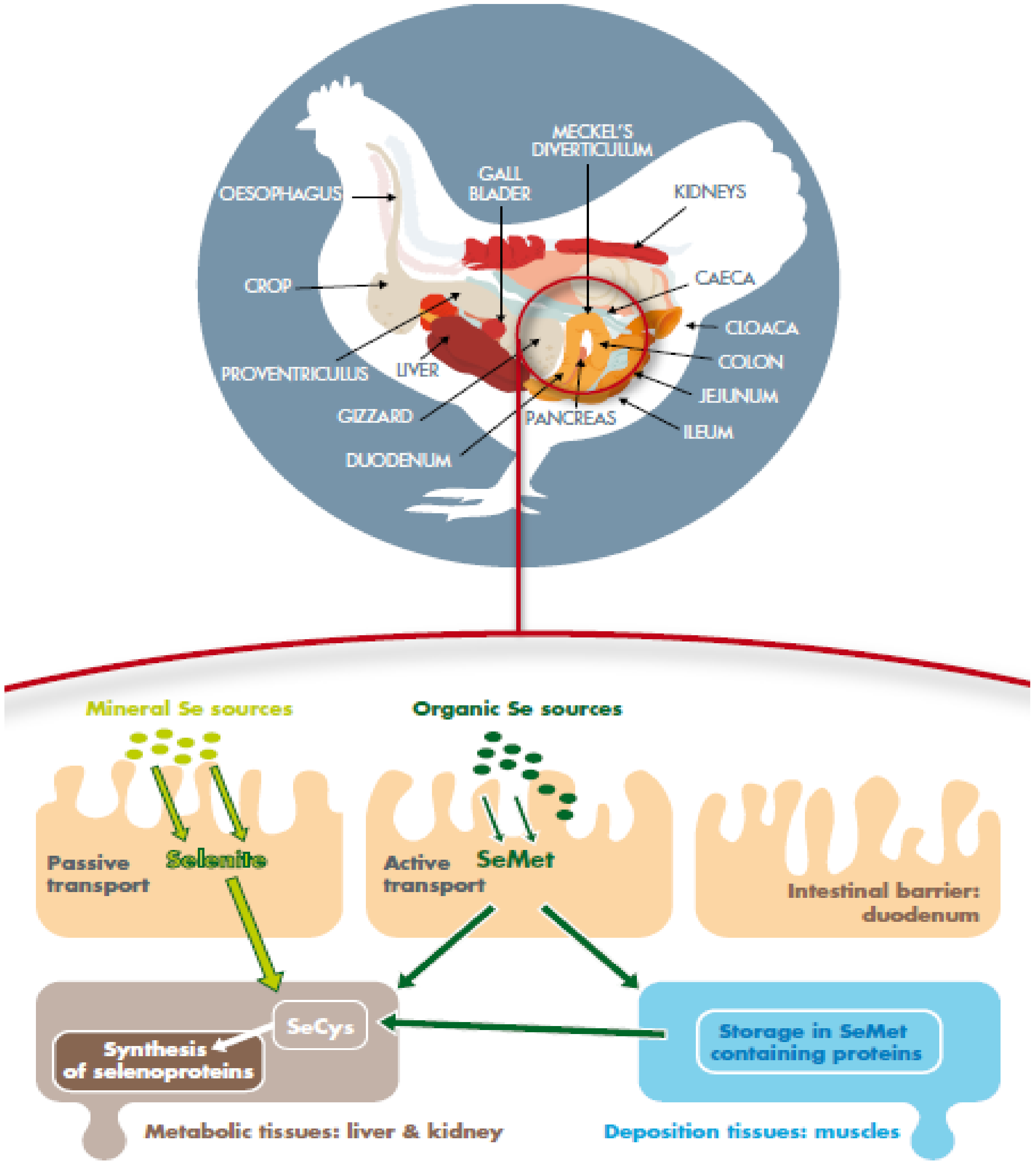
- AO defence Cell proliferation
- DNA-repair systems Cell differentiation
- Transfer of genetic information Stability of cell membrane
- Stress protein synthesis Stability of intracellular milieu
- Proteosomal function Macromolecular turnover
- Neutralisation and removing toxic chemicals Stress response
- Tissue regeneration and wound healing Hormonal response
- Tumour suppression Immune response
- Cell death and cell replacement Thermoregulation
- Neuronal response

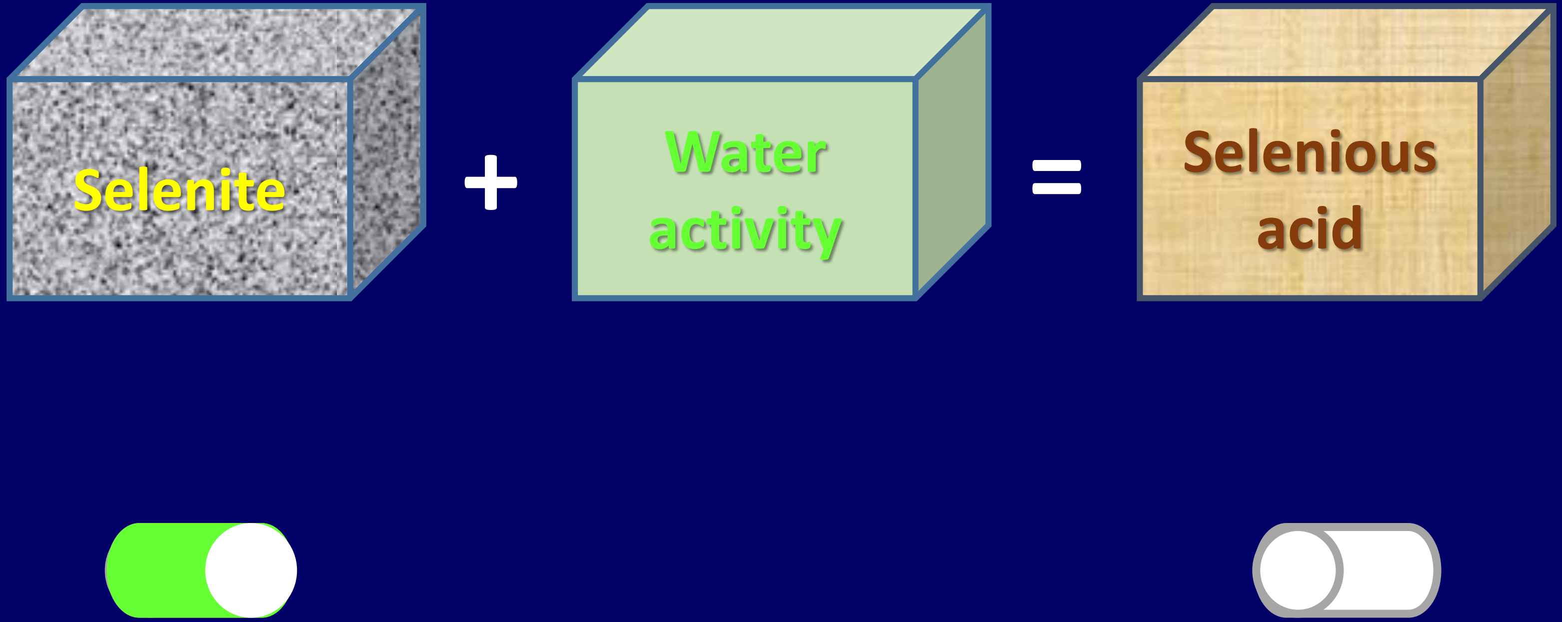


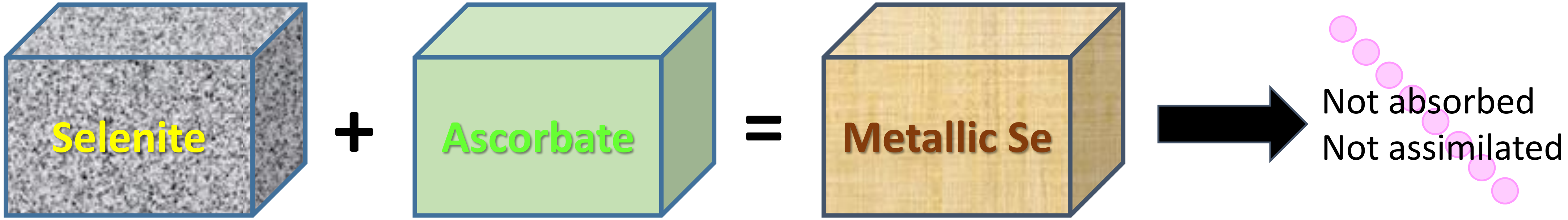
In particular, it was proven in an university-conducted trial that inclusion of anti-stress composition (PerforMax) into the drinking water improved chicken growth and feed conversion ratio (FCR; Fotina *et al.*, 2011, 2014). Using the same anti-stress composition under commercial conditions improved FCR during a 39 day broiler growth trial. The improvement in FCR due to the anti-stress composition during the first three days post-hatch, as well as before and after vaccination was highly significant (Velichko and Surai, 2014; Velichko *et al.*, 2013). The importance and efficacy of the anti-stress composition for rearing birds and adult egg type parent stock (Hy-Line) at one of the biggest egg producing farms in Russia (Borovskaya poultry farm, Tumen region) have been recently reviewed (Shatskich *et al.*, 2015).

Selenium absorption and metabolism

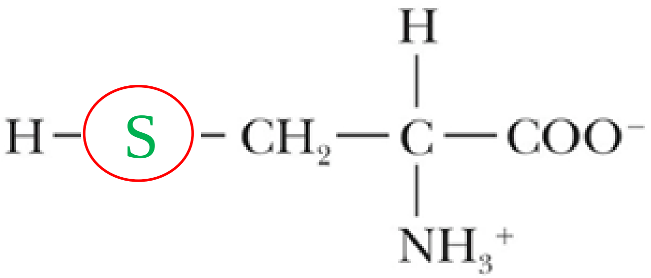
- ✓ Chemical form of Se
- ✓ Other dietary components
- ✓ Selenium status
- ✓ Physiological status
- ✓ Species


MECKEL'S DIVERTICULUM
GALL BLADER
KIDNEYS
OESOPHAGUS
CROP
CAECA
CLOACA
COLON
PROVENTRICULUS
LIVER
JEJUNUM
GIZZARD
PANCREAS
ILEUM
DUODENUM
Mineral Se sources
Organic Se sources
Passive transport
Selenite
Active transport
SeMet
Intestinal barrier: duodenum
SeCys
Synthesis of selenoproteins
Storage in SeMet containing proteins
Metabolic tissues: liver & kidney
Deposition tissues: muscles

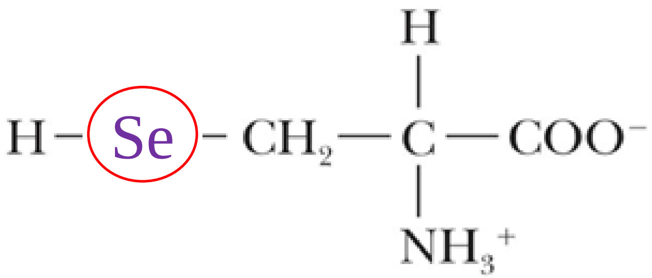

Selenite
+
Water activity
=
Selenious acid


Selenite
+
Ascorbate
=
Metallic Se
Not absorbed
Not assimilated

Synthesis Mechanism of 21st Amino Acid Selenocysteine

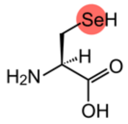


Cysteine

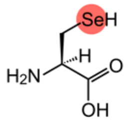


Selenocysteine

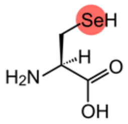
Key points



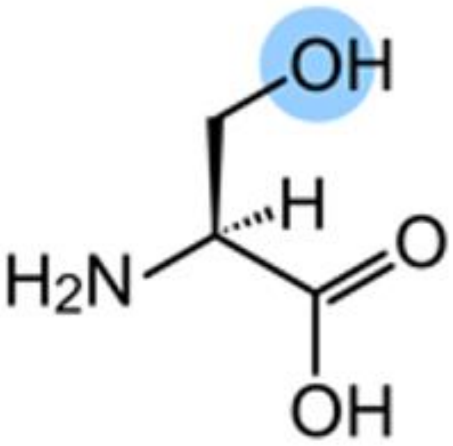
The three-dimensional structure of SelA, the enzyme required for selenocysteine (Sec) synthesis, is determined.



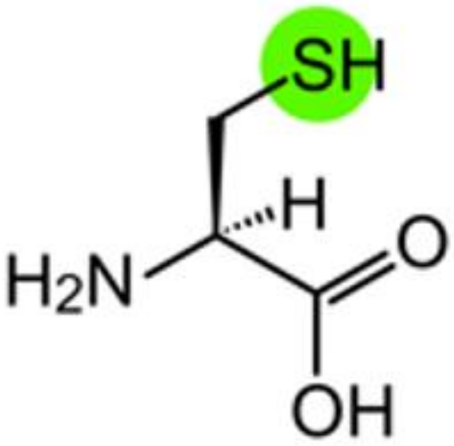
Four subunits of the huge star-shaped protein, SelA, play different roles in Sec synthesis on one tRNA.



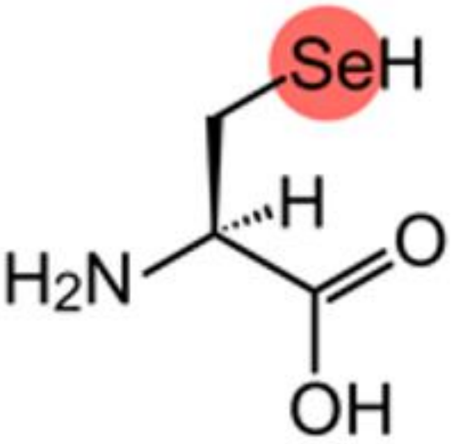
The findings will contribute to the development of super-enzymes by facilitating introduction of selenium (Se) into enzymes.



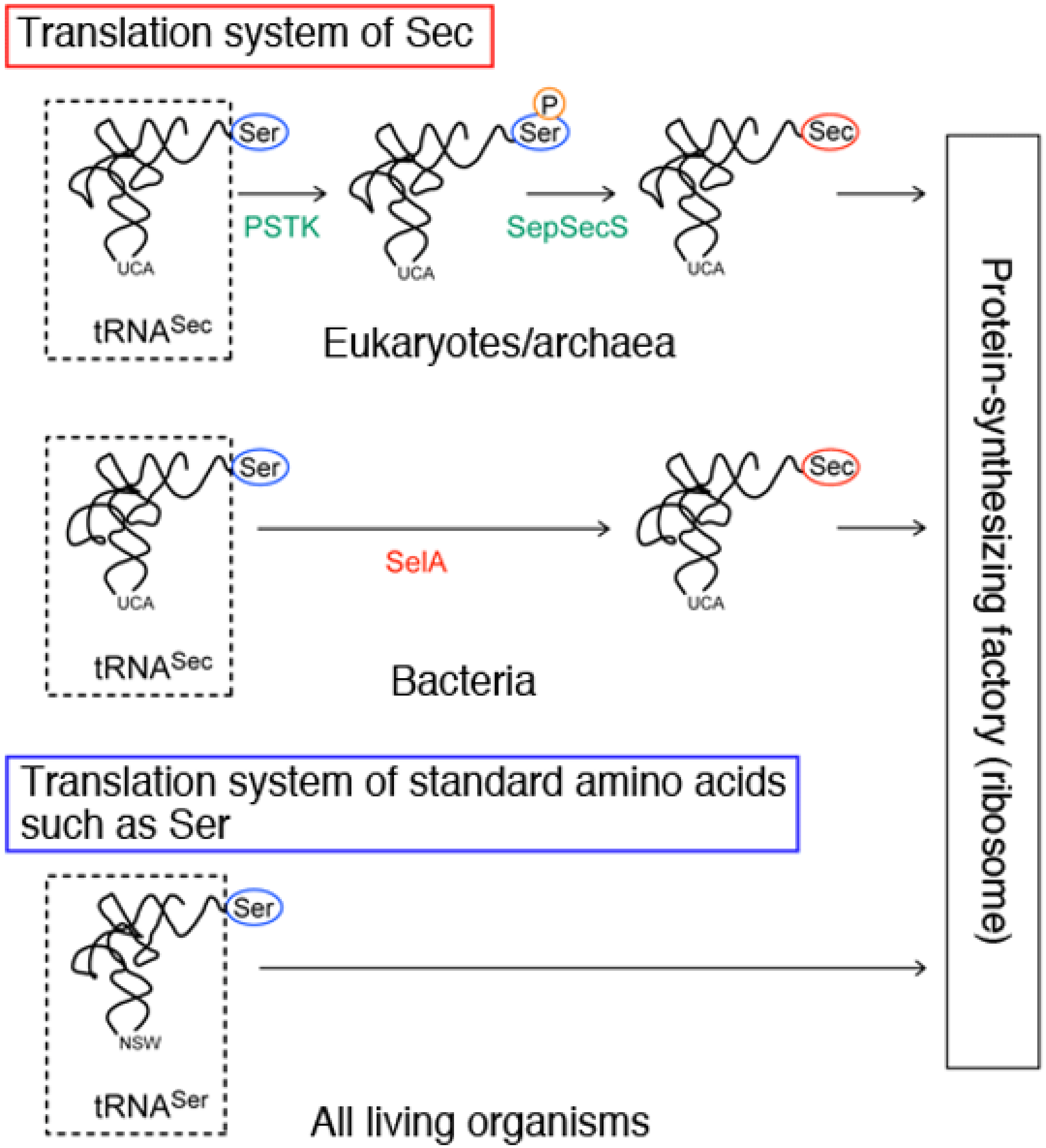
Serine (Ser)



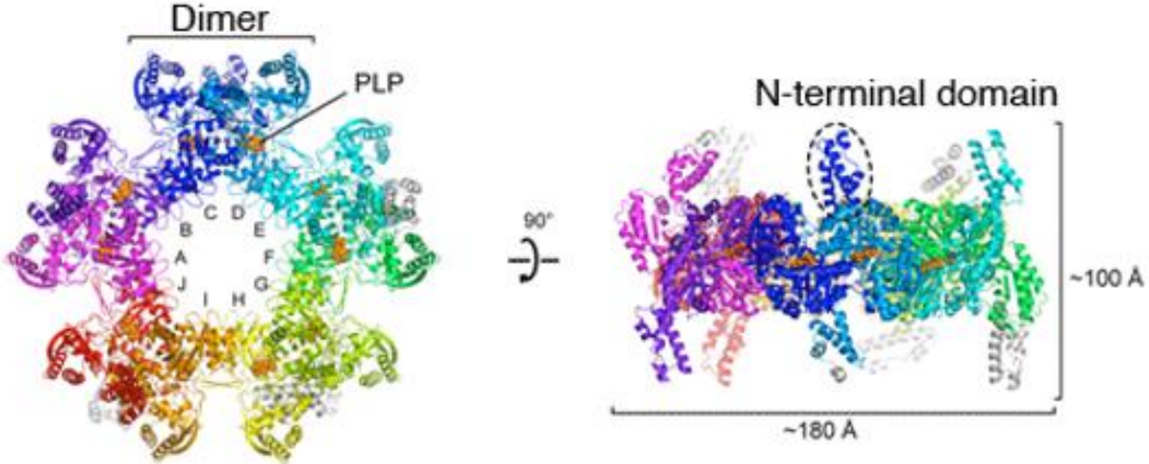
Cysteine (Cys)



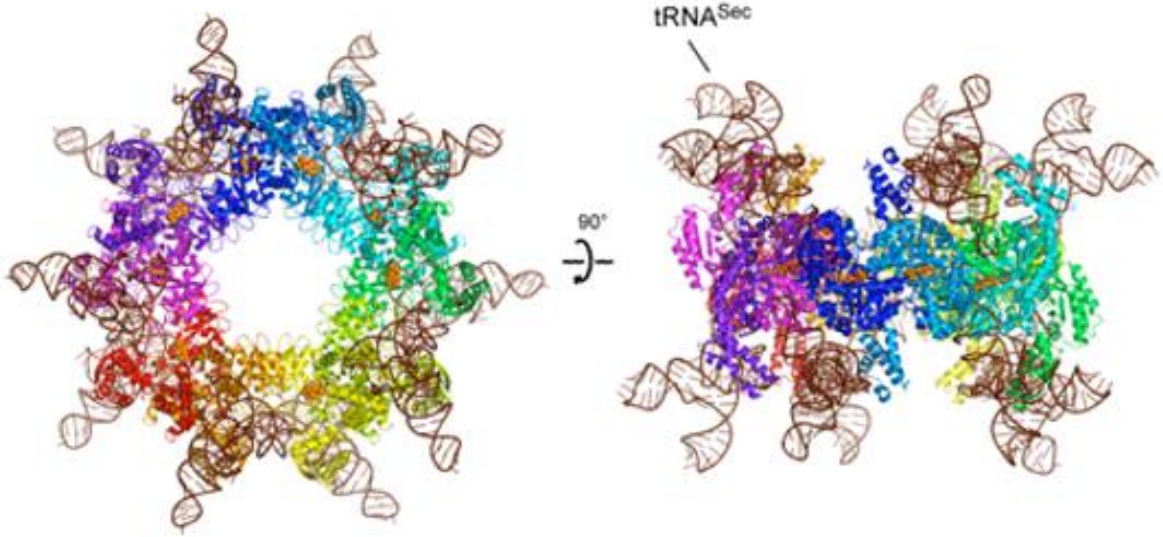
Selenocysteine (Sec)



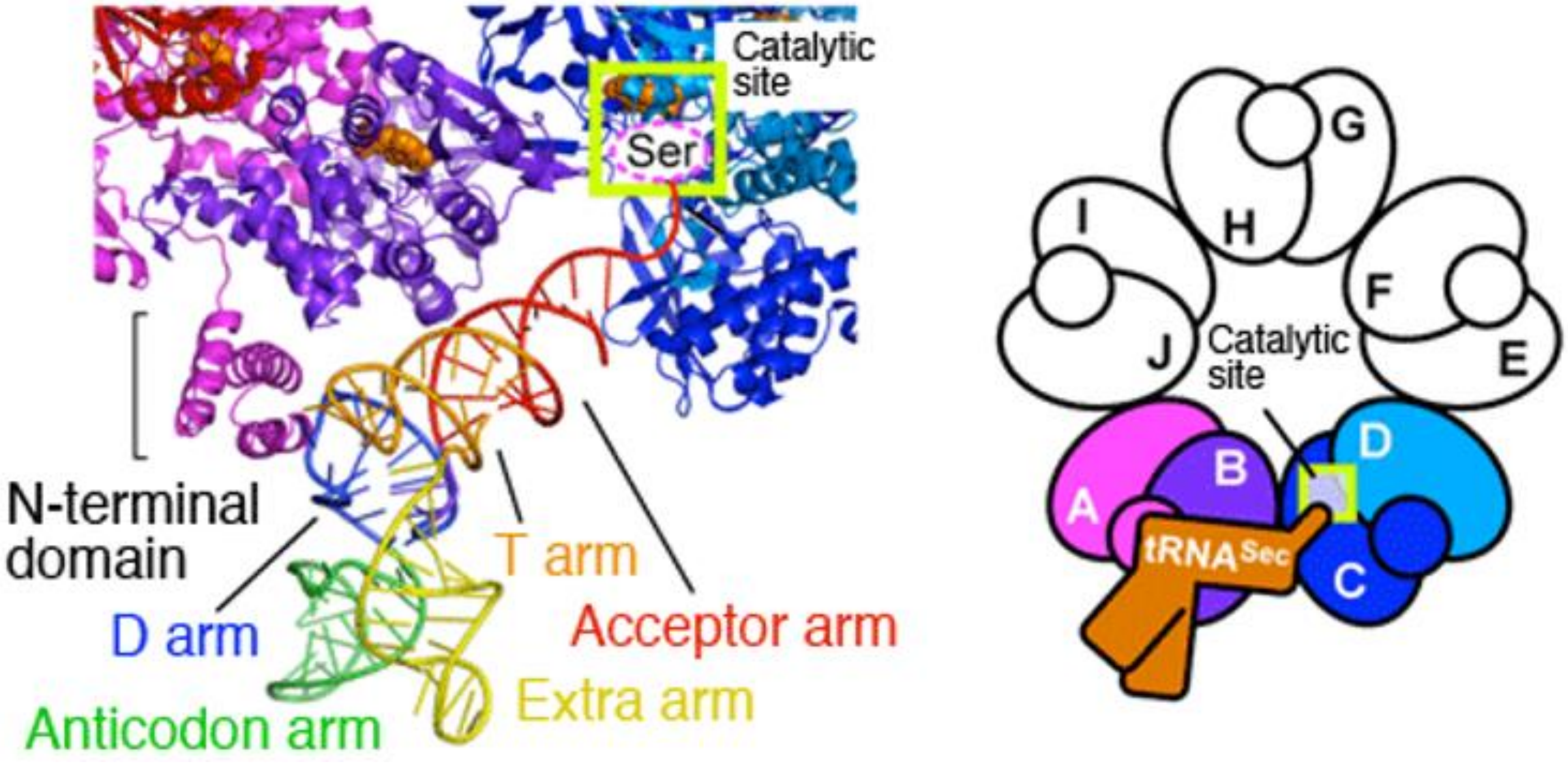
Translation system of Sec
Ser
P
Ser
Sec
PSTK
SepSecS
UCA
UCA
UCA
tRNA^Sec
Eukaryotes/archaea
Ser
Sec
SelA
UCA
UCA
tRNA^Sec
Bacteria
Translation system of standard amino acids such as Ser
Ser
NSW
tRNA^Ser
All living organisms
Protein-synthesizing factory (ribosome)



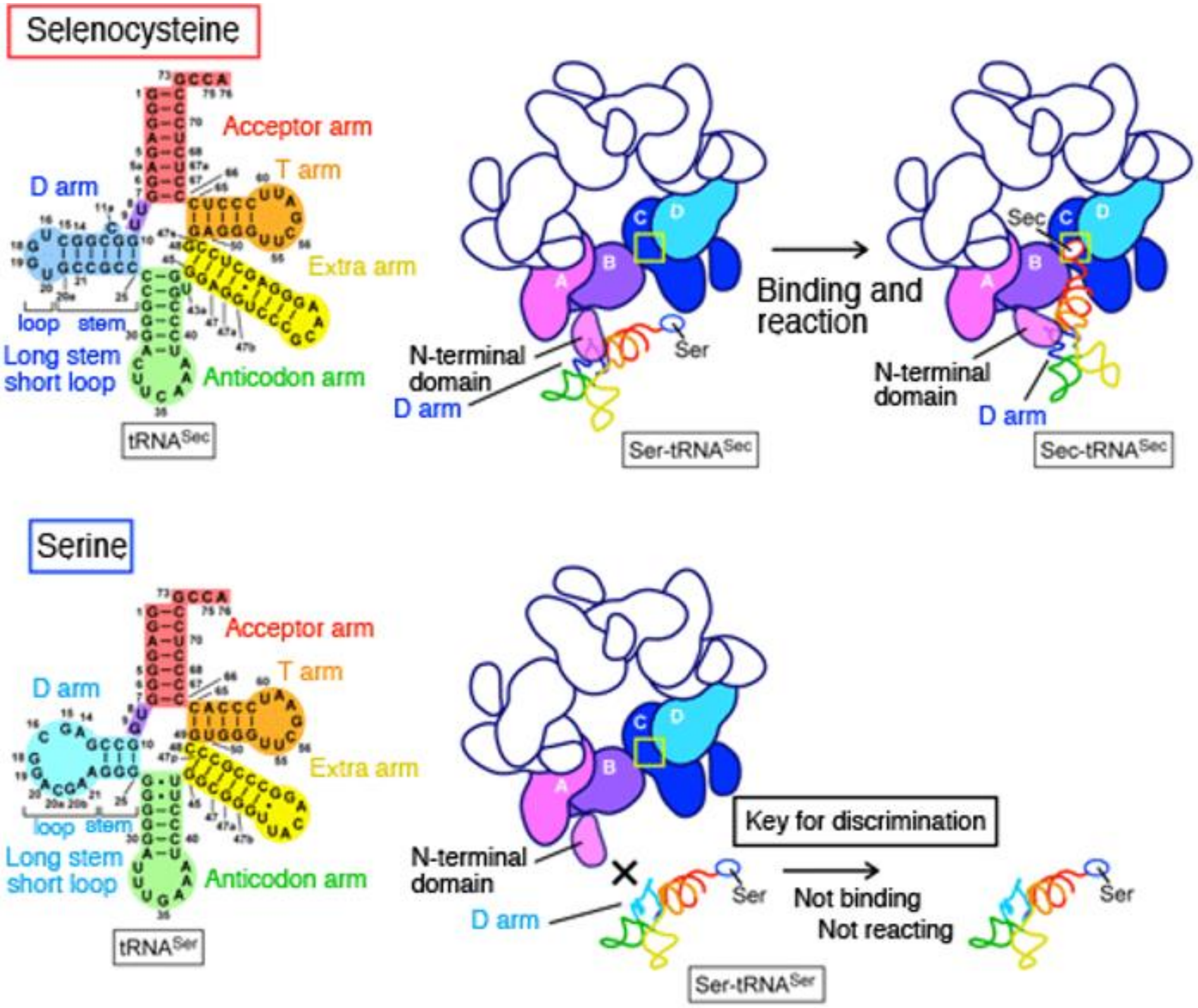
SelA without tRNASec



SelA•tRNASec complex



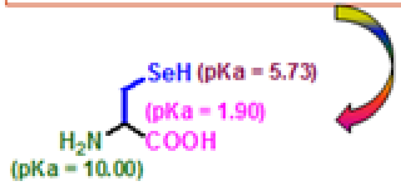
Catalytic site
Ser
N-terminal domain
D arm
T arm
Acceptor arm
Extra arm
Anticodon arm
G
I
H
F
J
E
Catalytic site
D
B
A
tRNA Sec
C


Selenocysteine
Acceptor arm
T arm
D arm
Extra arm
loop
stem
Long stem
short loop
Anticodon arm
tRNASec
N-terminal domain
D arm
Ser
Ser-tRNASec
Binding and reaction
Sec
N-terminal domain
D arm
Sec-tRNASec
Serine
Acceptor arm
T arm
D arm
Extra arm
loop
stem
Long stem
short loop
Anticodon arm
tRNASer
N-terminal domain
D arm
Ser
Key for discrimination
Not binding
Not reacting
Ser
Ser-tRNASer

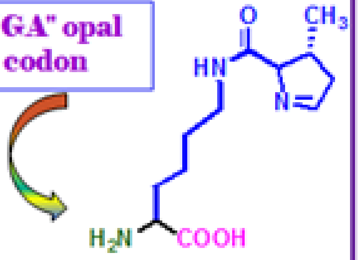
IV. “Special” 21st & 22nd Amino Acids

21st AA-Codes "UGA" opal (or umber) stop codon

22nd AA-Codes "UGA" opal (or umber) stop codon

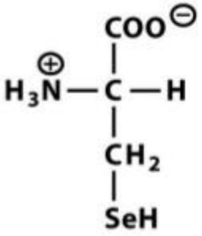


(S)-Selenocysteine
Sec
U



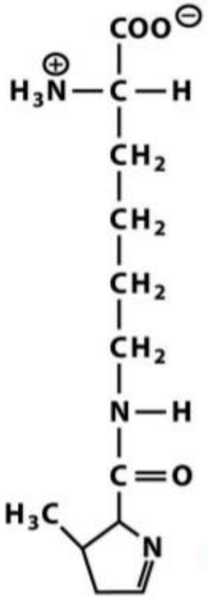
(S)-Pyrrolysine
Pyl
O

Other Amino Acids and Amino Acid Derivatives



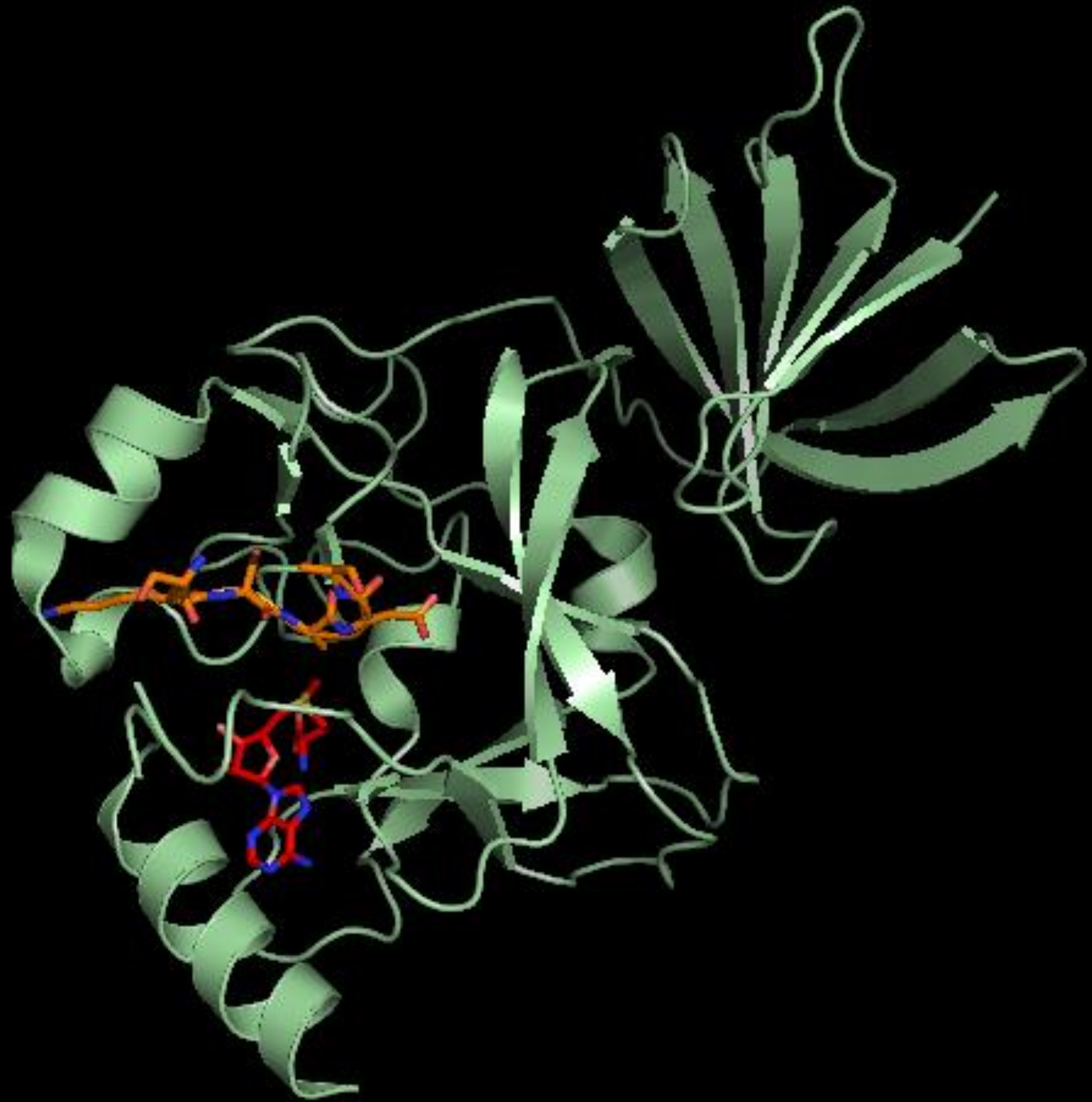
Selenocysteine

(21st amino acid)



(22nd amino acid)

Pyrrolysine

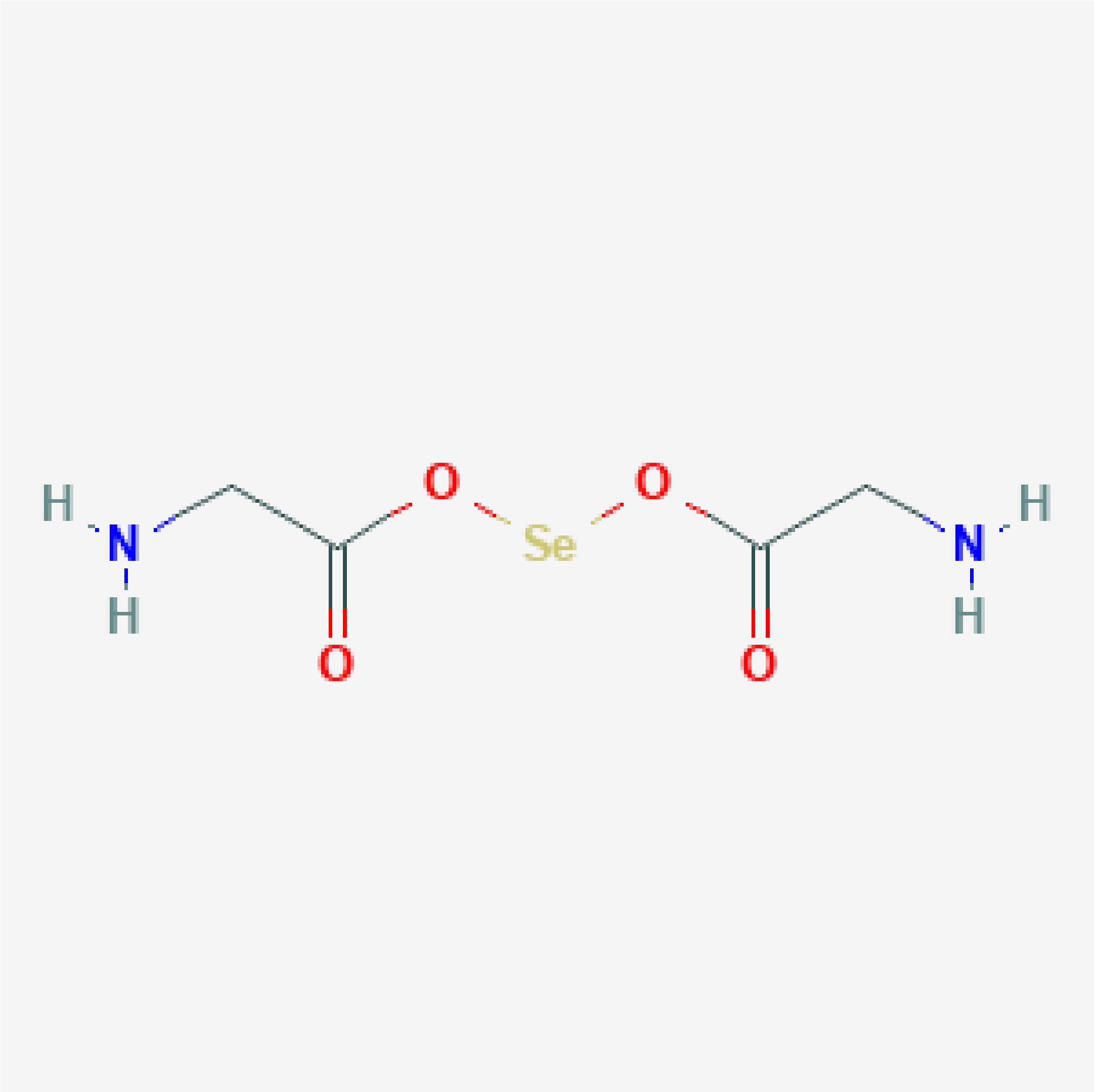


Chelated Selenium products

Se-glycinates
Se-proteinates
Se-amino acids complexes

The chemical position of Se in the periodic table of elements indicates that Se is not a true metal, and therefore its chelating ability is in question.

Chelated Se products are not related to SeMet or SeCys and, probably, should not be included into the organic Se category.



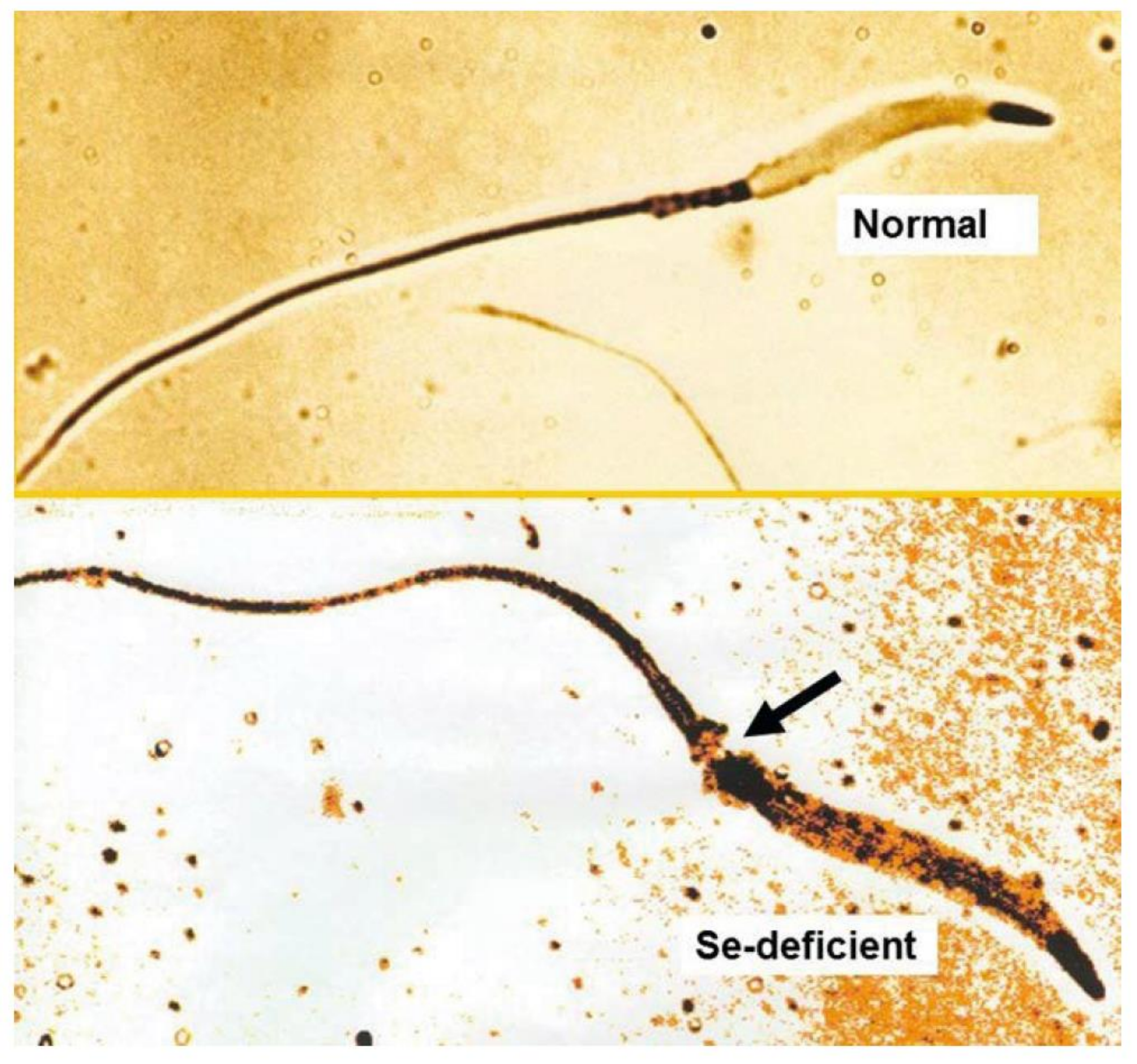
Selenium-enriched yeast

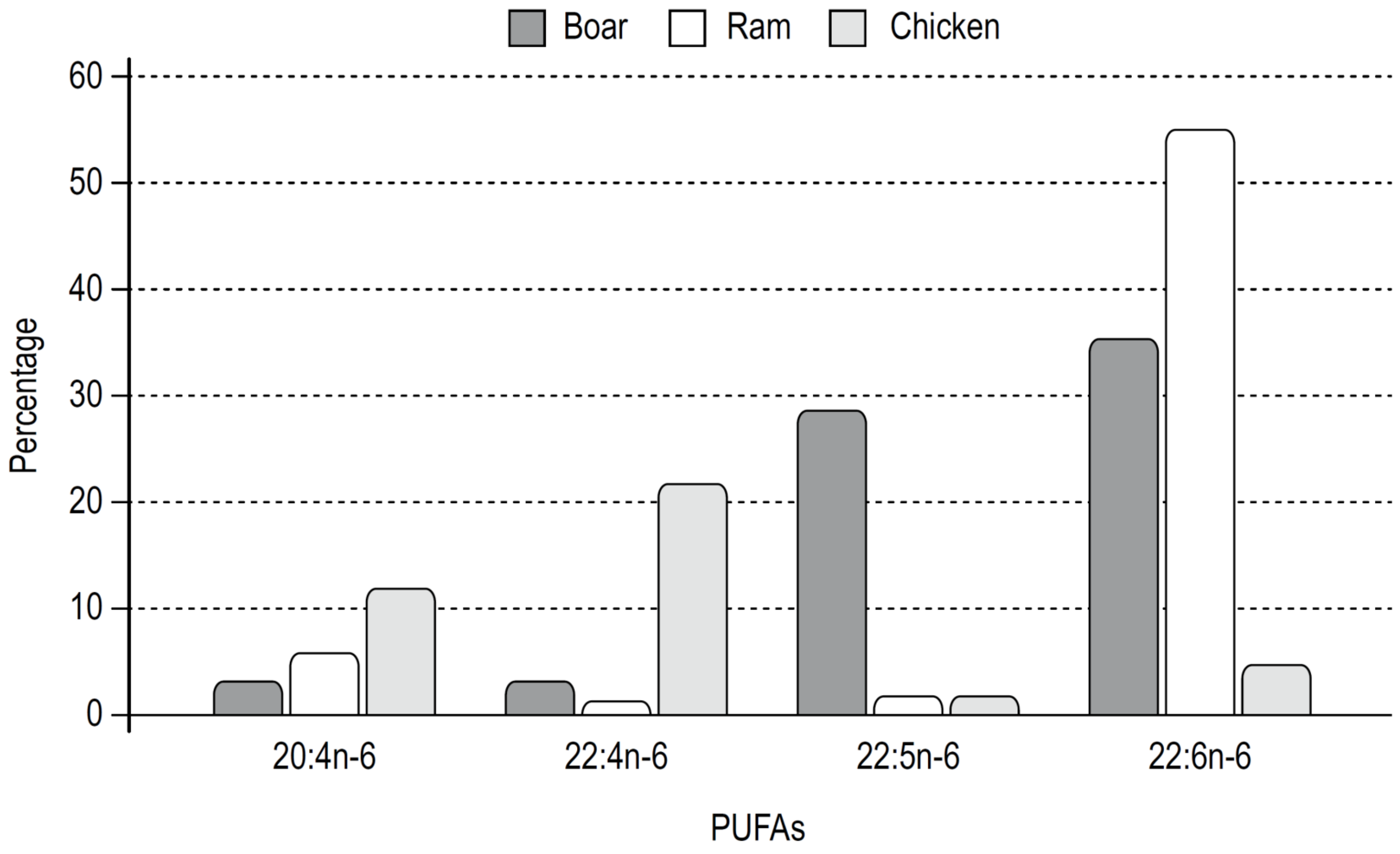
Saccharomyces Cerevisiae
inactivated yeast

- **50-70%** of Se as SeMet
- **10-15%** of Se as SeCy
- Fermentation process, Se composition depends on growing conditions
- **11.5%** to **28%** of water soluble Se
- **>50** Selenium species
- Variation of SeMet proportion from batch to batch

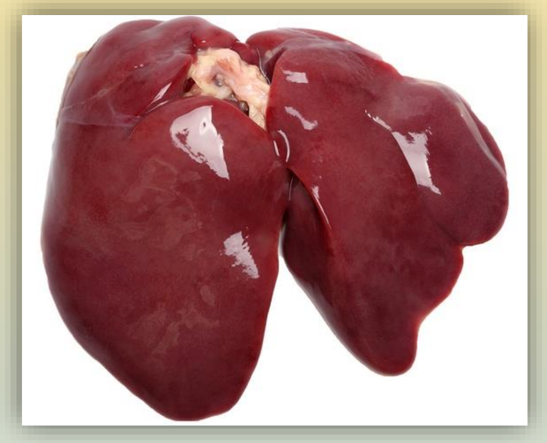
The legal definition of Se-yeast is as follows:

Selenium yeast is a dried, non-viable yeast (*Saccharomyces cerevisiae*) cultivated in a fed-batch fermentation which provides incremental amounts of cane molasses and selenium salts in a manner which minimises the detrimental effects of selenium salts on the growth rate of the yeast and allows for optimal incorporation of inorganic selenium into cellular organic material. Residual inorganic selenium is eliminated in a rigorous washing process and must not exceed 2% of the total selenium content in the final selenium yeast product (LII, 2015).


Normal
Se-deficient



Polyunsaturated fatty acids (PUFAs) in spermatozoa phospholipids, % (adapted from Surai, 2002).
20:4n-6 = arachidonic acid; 22:4n-6 = docosatetraenoic acid; 22:5n-6 = docosapentaenoic acid; 22:6n = 3 docosahexaenoic acid.



GSH-Px

GSH-Px

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An improvement in productive and reproductive performance of aged broiler breeder hens by dietary supplementation of organic selenium

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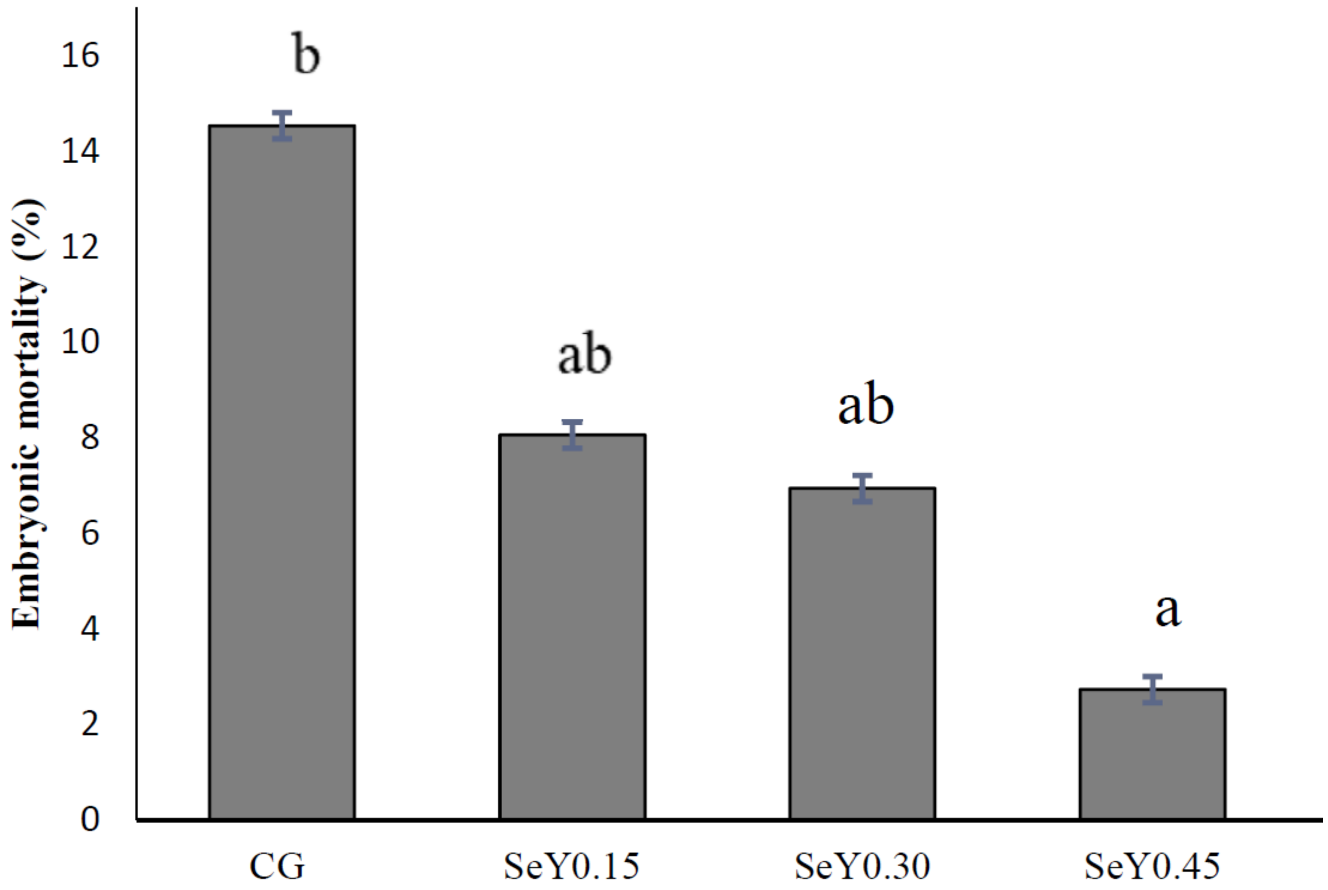
Embryonic mortality (%)
16
14
12
10
8
6
4
2
0
b
ab
ab
a
CG
SeY0.15
SeY0.30
SeY0.45


DIET CURES,
MORE THAN THE LANCET