**2-HG** - 2-Hydroxyglutarate
**3-PHP** - 3-Phosphate Hydroxypyruvate
**3-Pser** - 3-Phosphoserine
**4AB** - 4-Aminobutyraldehyde
**4ABT** - 4-Aminobutyrate Transaminase
**4Fe-4S** - Tetrakis(1+ atom(1+) ion) Tetrasulfane Tetrasulfanide
**4-HB** - 4-Hydroxybenzoic Acid
**4-HBA** - 4-Hydroxybenzaldehyde
**4-HBS** - 4-Hydroxybenzoate Synthase
**4-HCA** - 4-Hydroxycinnamic Acid
**4-Mel** - 4-Methylimidazole
**4-MeIA** - Methylimidazole Acetate
**4-MeIAase** - 4-Methylimidazole Acetate Hydrolase
**5-HIA** - 5-Hydroxyindoleacetaldehyde
**5-HIAA** - 5-Hydroxyindoleacetic acid
**5-MTHF** - 5-Methyltetrahydrofolate
**5,10-MTHF** - 5,10-MethyleneTetraHydroFolate
**6PGL** - 6-Phosphoglucono-δ-Lactone
**6PG** - 6-Phosphogluconate
**6PGD** - 6-Phosphogluconate Dehydrogenase
**AA** - Amino Acids
**AAA** - Acetoacetic Acid
**AAC** - Acetoacetyl-CoA
**AAD** - Acetoacetate Decarboxylase
**AADC** - Aromatic L-Amino Acid Decarboxylase
**AAO** - L-Amino-Acid Oxidase
**AC** - Acontase
**ACC** - Acetyl-CoA Carboxylase
**ACMS** - 2-Amino-3-Carboxymuconic-6-Semialdehyde Acid
**ACSM1/2B** - Mitochondrial Medium-chain Acyl-CoA Synthetases
**A-CoA** - Acetyl-CoA
**AChE** - Acetylcholinesterase
**ACOD** - cis-Aconitate Decarboxylase
**ACS** - Acetyl-CoA Synthetase
**ACTH** - Adrenocorticotropic Hormone
**ADC** - Arginine Decarboxylase
**ADK** - Adenylate Kinase (Myokinase)
**ADH** - Alcohol Dehydrogenase
**ADHFE** - Hydroxyacid-Oxoacid Transhydrogenase
**ADO** - 2-Aminoethanethioldioxygenase
**AdoCbl** - Adenosylcobalamin
**ADP** - Adenosine Diphosphate
**ADS** - Adenylosuccinate
**ADSL** - Adenylsuccinate Lyase
**ADSS** - Adenylosuccinate Synthetase
**AFMID** - Kynurenine Formamidase
**AGAT** - Arginine:Glycine Amidinotransferase
**AGXT** - Alanine-Glyoxylate Aminotransferase
**AICAR** - 5-Aminoimidazole-4-Carboxamide Ribonucleotide
**AIR** - 5-Aminoimidazole Ribonucleotide
**AIRS** - AIR Synthetase
**α-KB** - α-Ketobutyrate
**α-KG** - α-Ketoglutarate
**α-KGDH** - alpha-Ketoglutarate Dehydrogenase
**Ala** - Alanine
**ALD** - Aldolase
**ALDH** - Aldehyde Dehydrogenase
**ALP** - Alkaline Phosphatase
**ALT** - Alanine Aminotransferase
**AMP** - Adenosine Monophosphate
**AMPD** - AMP Deaminase
**AMPK** - AMP-activated Protein Kinase
**ARG1** - Arginase
**AGS** - Agmatinase
**AR** - Aldose Reductase
**AO** - Aldehyde Oxidase
**APS** - Adenosine-5′-Phosphosulfate
**APSK** - APS Kinase
**ASA** - Argininosuccinate
**ASDC** - Aspartate Decarboxylase
**ASL** - Argininosuccinate Lyase
**Asp** - Aspartate
**ASPT** - Aspartate Transcarbamoylase
**ASS** - Argininosuccinate Synthetase
**AST** - Aspartate Aminotransferase
**ASMT** - Acetylserotonin O-Methyltransferase
**ATP** - Adenosine Triphosphate
**BH2** - Dihydrobiopterin
**BH4** - Tetrahydrobiopterin
**BHB** - β-hydroxybutyric Acid
**BHMT** - Betaine-Homocysteine S-methyltransferase
**BPG** - Biphosphoglycerate
**BPGM** - BPG Mutase
**BPGP** - 2,3 BPG Phosphatase
**Br** - Bromine
**Ca** - Calcium
**CAIR** - 5-Aminoimidazole-4-Carboxylate Ribonucleotide
**cAMP** - Cyclic Adenosine Monophosphate
**Car** - Carnosine
**Car-AcAl-IA** - Carnosine-Acetaldehyde-Imidazolidinone Adduct
**CAT** - Catalase
**CBS** - Cystathionine B-Synthase
**CSAD** - Cysteine Sulfinic Acid Decarboxylase
**CDO** - Cysteamine Dioxygenase
**CDP** - Cytidine 5′-Diphosphate
**CK** - Creatine Kinase
**CGL** - Cystathionine gamma-Lyase
**ChAT** - Choline Acetyltransferase
**CHDH** - Choline Dehydrogenase
**Cl** - Chloride
**CMP** - Cytidine Monophosphate
**CMPK** - UMP-CMP Kinase
**CNMT** - Carnosine N-Methyl Transferase
**CNDP** - Cytosolic Non-Specific Dipeptidase
**CO** - Carbon Monoxide
**$CO_2$** - Carbon Dioxide
**Co** - Cobalt
**CoA** - Coenzyme A
**CoAH** - CoA Hydrolase
**COMT** - Catechol O-methyltrans
**CP** - Carbamoyl Phosphate
**CPS1** - Carbamoyl Phosphate Synthase1
**CR** - Carbonyl Reductase
**Cr** - Chromium
**Cre** - Creatine
**CRH** - Corticotrophin-Releasing Hormone
**CRNS** - Carnosine Synthase
**CS** - Citrate Synthase
**CSE** - Cystathionase
**CTP** - Cytidine 5′-Triphosphate
**Cu** - Copper
**CYP** - Cytochrome P450 monooxygenase
**DAT** - Dopamine Transporter
**DAO** - Diamine Oxidase
**DBH** - Dopamine Beta Hydroxylase
**DHBA** - 3,4-Dihydroxybenzeneacetic Acid
**DHF** - Dihydrofolate
**DHFR** - Dihydrofolate Reductase
**DHI** - 5,6-Dihydroxyindole
**DHICA** - 5,6-Dihydroxyindole-2-Carboxylic Acid
**DHMA** - 3,4-Dihydroxymandelaldehyde
**DHMC** - 3,4-Dihydroxymandelic Acid
**DMG** - Dimethylglycine
**DMGDH** - DMG Dehydrogenase
**DHO** - Dihydroorotate
**DHOase** - Dihydroorotase
**DHODH** - Dihydroorotate Dehydrogenase
**DOPAC** - 3,4-Dihydroxyphenylacetic Acid
**DOPAL** - 3,4-Dihydroxyphenylacetaldehyde
**DPCK** - DephosphoCoA Kinase
**DT** - L-Dopachrome Tautomerase
**dTMP** - Thymidine Monophosphate
**dUMP** - Deoxyuridine Monophosphate
**E4P** - Erythrose-4-Phosphate
**ENO** - Enolase
**ENPP** - Ectonucleotide Pyrophosphatase/Phosphodiesterase
**ETHE1** - Sulphur Dioxygenase
**F1,6BP** - Fructose 1,6-Biphosphate
**F2,6BP** - Fructose 2,6-Biphosphate
**F6P** - Fructose-6-Phosphate
**FAA** - 4-Fumarylacetoacetic Acid
**FAAS** - Fumarylacetoacetase
**FAD** - Adeflavin
**FADS** - FAD Synthetase
**FAICAR** - 5-Formamidoimidazole-4-Carboxamide Ribonucleotide
**FBPase** - Fructose 1,6-Biphosphatase
**FBPase2** - Fructose 2,6-Biphosphatase
**Fe** - Ferritin
**FGAM** - Formylglycinamidine Ribonucleotide
**FGAR** - Formylglycinamide Ribonucleotide
**FIGLU** - Formimidoylglutamic Acid
**FIGLU-THF** - Formiminoglutamate-THF
**FMN** - Flavin Mononucleotide
**FMO** - Flavin Monooxygenase
**FOLH** - Folate Hydrotase
**FS** - Fumarase
**FT** - Formiminotransferas
**FTase** - AICAR Transformylase
**FTCD** - Formiminotransferase Cyclodeaminase
**G3P** - Glyceraldehyde-3-Phosphate
**G6Pase** - Glucose 6-Phosphotase
**G6PD** - Glucose-6-Phosphate Dehydrogenase
**GABA** - Gamma-Aminobutyric Acid
**GAD** - Glutamate Decarboxylase
**GAG** - Glycosaminoglycan
**GAMT** - S-Adenosylmethionine:Guanidinoacetate Methyltransferase
**GAPDH** - Glyceraldehyde 3-Phosphate Dehydrogenase
**GARS** - GAR Synthetase
**GARTase** - GAR Transformylase
**GAT** - Guanidinoacetate
**γBBH** - γ-Butyrobetaine Hydroxylase
**GCA** - γ-Glutamylcysteine Synthetase
**GCH1** - GTP Cyclohydrolase I
**GDP** - Guanosine Diphosphate
**GDH** - Glutamate Dehydrogenase
**GFAT** - Glutamine:Fructose-6P Amidotransferase
**GHB** - γ-Hydroxybutyrate
**GK** - Glucokinase
**Glc-1,6-BP** - Glucose-1,6-Biphosphate
**GlcNAc** - N-Acetylglucosamine
**GlcNAc-1-P** - GlcNAc 1-Phosphate
**GlcNAc-6-P** - GlcNAc 6-Phosphate
**GLN** - Glutaminase
**Gln** - Glutamate
**GLS** - Glutathione Synthase
**GLSH** - Glutamate Dehydrogenase
**Gly** - Glycine
**GLYDH** - Glycolaldehyde Dehydrogenase
**GLYP** - Glycogen Phosphorylase
**GLYS** - Glycogen Synthase
**Glut** - Glutamate
**GNMT** - Glycine N-Methyltransferase
**GOR** - Glyoxylate Reductase
**GOX** - Glycolate Oxidase
**GPX** - Glutathione Peroxidase
**GR** - Glutathione Reductase
**GS** - Glutamine Synthetase
**GSA** - Glutamate-5-Semialdehyde
**GSH** - Glutathione, reduced
**GSK3β** - Glycogen Synthase Kinase-3 beta
**GSSG** - Glutathione disulfide (oxidised)
**GSSH** - Glutathione Persulfide
**GTP** - Guanosine Triphosphate
**GTase** - Glycosyltransferases
**H** - Hydrogen
**$H_2O$** - Water
**$H_2O_2$** - Hydrogen Peroxide
**H2S** - Hydrogen Sulfide
**H2NTP** - 7,8-Dihydroneopterin Triphosphate
**HAAO** - 3-Hydroxyanthranilic Acid Dioxygenase
**HAL** - Histidine Ammonia-Lyase
**HAS** - Hyaluronic Acid Synthase
**HBDH** - Hydroxybutyrate Dehydrogenase
**$HCO_3$** - Bicarbonate
**HK** - Hexokinase
**HIF** - Hypoxia-Inducible Factor
**HGA** - Homogentisic Acid
**HGD** - Homogentisate 1,2-dioxygenase
**HMPAL** - 3-Methoxy-4-Hydroxyphenylacetaldehyde
**HMT** - Histidine Methyltransferase
**HOGA** - 4-Hydroxy-2-Ketoglutarate Aldolase
**HPCL** - HydroxyPyruvate Carboxy-Lyase
**HPRT** - Hypoxanthine-Guanine Phosphoribosyltransferase
**HT** - Histidine Transaminase
**HTMLA** - β-hydroxy-ε-N-trimethyllysine aldolase
**HTDH** - Hypotaurine Dehydrogenase
**HVA** - Homovanillic Acid
**HYPDH** - 4-Hydroxyproline Dehydrogenase

**I** - Iodine
**IAA** - Imidazole Acetaldehyde
**IAcA** - Imidazole Acetic Acid
**IAL** - Imidazoleacetate-Lyase
**ICL** - Isocitrate Lyase
**IDH** - Isocitrate Dehydrogenase
**IDO** - Indoleamine 2,3-Dioxygenase
**IFN** - Interferon
**IMP** - Inosine Monophosphate
**IMPDH** - IMP Cyclohydrolase
**IP3** - Inositol Trisphosphate
**iQ** - Indole-5,6-Quinone
**K** - Potassium
**KAT** - Kynurenine Aminotransferase
**KMO** - Kynurenine 3-Monooxygenase
**KYNU** - Kynureninase
**LDH** - Lactate Dehydrogenase
**LPA** - Lipoamide
**LPH4** - Lactoyl-PH4
**MAA** - Maleylacetoacetic Acid
**MAAI** - Maleylacetoacetate Isomerase
**MAS** - Malate Synthase
**MAO** - Monoamine Oxidase
**MDH** - Malate Dehydrogenase
**ME1** - NADP-dependent Malic Enzyme
**MeCBL** - Methylcobalamin
**MetHb** - Methemoglobinemia
**Mg** - Magnesium
**MHPG** - 3-Methoxy-4-Hydroxyphenylglycolaldehyde
**MIF** - Macrophage Migration Inhibitory Factor
**MMC-M** - MethylMalonyl-CoA Mutase
**MMC-R** - MethylMalonyl-CoA Racemase
**MMP** - Matrix Metalloproteinase
**Mn** - Manganese
**Mo** - Molybdenum
**Mo-MPT** - Mo-Molybdopterin
**MS** - Methionine Synthase
**MTA** - 5′-Methylthioadenosine
**MTHFR** - MethyleneTetraHydroFolate Reductase
**MTR** - 3-Methoxytyramine
**NTSC2** - Cytosolic 5′-nucleotidase II
**Na** - Sodium
**N-Ac-Put** - N-Acetyl-Putrescine
**N-Ac-ABAL** - N-Acetyl-Gamma-Aminobutyraldehyde
**N-Ac-GABA** - N-Acetyl-Gamma-Aminobutyrate
**NAD** - Nicotinamide Adenine Dinucleotide
**NADK** - NAD Kinase
**NADPT** - NAD(P)+ Transhydrogenase
**NADSYN** - NAD Synthetase
**NAGK** - N-Acetylglucosamine Kinase
**NAM** - Nicotinamide
**NAMPT** - Nicotinamide Phosphoribosyltransferase
**NAPRT** - Nicotinate Phosphoribosyltransferase
**N-AS** - N-Acetylspermine
**N-ASD** - N-Acetylspermidine
**NCS** - Norcoclaurine Synthase
**NDPK** - Nucleoside Diphosphokinase
**NET** - Norepinephrine Transporter
**$NH_3$** - Ammonia
**NMNAT** - Nicotinamide Mononucleotide Adenylyltransferase
**NO** - Nitric Oxide
**NOS** - Endothelial Nitric Oxide Synthase
**$O_2$** - Oxygen
**OAA** - Oxaloacetate
**OAT** - Ornithine 2-Oxo-Acid-ADP-Ribose
**OAT** - Ornithine Aminotransferase
**ODC** - Ornithine Decarboxylase
**OH-ENP** - 4-Hydroxy-Enol-Phenylpyruvate
**OH-Glut** - 4-Hydroxyglutamate
**OH-GlutSA** - 4-Hydroxyglutamate Semialdehyde
**OH-KG** - 4-Hydroxy-2-Ketoglutarate
**OH-P5C** - Pyrroline Hydroxycarboxylate
**OH-PD** - 4-Hydroxyphenylpyruvate Dioxygenase
**OH-PH4** - 1-Hydroxy-2-Oxopropyl Tetrahydropterin
**OH-PLA** - Hydroxyphenyllactic Acid
**OH-PPA** - 4-Hydroxyphenylpyruvic Acid
**OH-PPD** - 4-Hydroxyphenyl-Pyruvate Dioxygenase
**OH-Pyr** - Hydroxypyruvate
**OMP** - Orotidine-5′-Monophosphate
**OMPDC** - OMP Decarboxylase
**OPRT** - Orotate Phosphoribosyltransferase
**OTC** - Ornithine Transcarbamoylase
**OX** - Oxalate
**OXH** - Oxaloacetase
**PSC** - Pyrroline-5-Carboxylate
**P5C** - P5C Reductase
**P5P** - Pyridoxal 5′-Phosphate
**PAA** - Phenylacetic Acid
**PAcAL** - Phenylacetaldehyde
**PAGM** - Phosphoacetylglucosamine Mutase
**PAGS** - Phenylacetylglutamine Synthetase
**PAH** - Phenylalanine Hydroxylase
**PAICS,C** - AIR carboxylase
**PAICS,N** - SAICAR synthetase
**PAL** - Pyruvaldehyde
**PAMOAT** - Pyridoxamine:Oxaloacetate Aminotransferase
**PANK** - Pantetheine Kinase
**PAO** - Polyamine Oxidase
**PAP** - Adenosine 3′,5′-Diphosphate
**PAPS** - 3′-Phosphoadenosine-5′-Phosphosulfate
**PAT** - Phenylalanine Aminotransferase
**PATK** - Panthenate Kinase
**PC** - Phosphocreatine
**PCB** - Pyruvate Carboxylase
**PCC** - Propionyl-CoA Carboxylase
**PDH** - Pyruvate Dehydrogenase
**PEPC** - Phosphoenolpyruvate Carboxylase
**PEPCK** - Phosphoenolpyruvate Carboxykinase
**PFAS** - Phosphoribosylformylglycinamidine Synthase
**PFK 1** - 6-Phosphofructokinase
**PFK 2** - 6-Phosphofructo-2-Kinase
**PGAM** - Phosphoglycerate Mutase
**PGC1α** - PPAR-gamma Coactivator 1-Alpha
**PGI** - Phosphoglucose Isomerase
**PGK** - Phosphoglycerate Kinase
**PGLS** - 6-Phosphogluconolactonase
**PGM** - Phosphoglucomutase
**PHCDH** - Pyrroline-3 hydroxy-5-carboxylate Dehydrogenase
**PHD** - Prolyl Hydroxylase
**PHGDH** - Phosphoglycerate Dehydrogenase
**PHT** - Phenylpyruvate Tautomerase
**Pi** - Phosphate
**PK** - Pyridoxal Kinase
**PKM** - Pyruvate Kinase
**PKA** - Protein Kinase A
**PKC** - Protein Kinase C
**PLA** - Phenylactic Acid
**PLD** - Prolidase
**PMP** - Pyridoxamine 5′-Phosphate
**PNMT** - Phenylethanolamine N-Methyltransferase
**PNP** - Purine Nucleoside Phosphorylase
**PNPO** - Pyridoxine 5′-Phosphate Oxidase
**PPA** - Phenylpyruvic Acid
**PPAR** - Peroxisome Proliferator-Activated Receptor
**PPAT** - Amidophosphoribosyltransferase
**PPP** - Pyridoxal Phosphate Phosphatase
**PPi** - Pyrophosphate
**PPCDC** - Phosphopantothenoylcysteine Decarboxylase
**PPCS** - Phosphopantothenoylcysteine Synthetase
**PPDC** - Phenylpyruvate Decarboxylase
**PQQ** - Pyrroloquinoline Quinone
**PRA** - 5-Phosphoribosylamine
**PRODH** - Proline Dehydrogenase
**PRPP** - 5-Phosphoribosyl-1-Pyrophosphate
**PRPS** - Phosphoribosyl Pyrophosphate Synthetase
**PSP** - Protein Synthesis Pathway
**PS** - Phosphatidyl Serine
**PSAT** - Phosphoserine Aminotransferase
**PSPH** - Phosphoserine Phosphatase
**PSS** - Phosphatidylserine Synthase
**PTP** - 6-Pyruvoyl-Tetrahydropterin
**PTPS** - 6-Pyruvoyl-Tetrahydropterin Synthase
**Pyr** - Pyruvate
**Q** - Ubiquinone (Coenzyme Q10)
**Qu** - Ubiquinol (Reduced Coenzyme Q10)
**Qu** - Quinuine
**Qus** - Queuosine
**QRPT** - Quinolinate Phosphoryltransferase
**R1P** - Ribose-1-Phosphate
**R5P** - Ribose-5-Phosphate
**RBKS** - Ribokinase
**RK** - Riboflavin Kinase
**ROS** - Reactive Oxygen Species
**RPE** - Ribulose-5-Phosphate 3-Epimerase
**RPIA** - Ribose-5-Phosphate Isomerase A
**Ru5P** - Ribulose-5-Phosphate
**S7P** - Sedoheptulose-7-Phosphate
**SAH** - S-Adenosyl-L-Homocysteine
**SAICAR** - 5-Aminoimidazole-4-(N-succinylcarboxamide) Ribonucleotide
**SAMe** - S-Adenosylmethionine
**SAMeA** - S-Adenosylmethionamine
**SAMeD** - S-Adenosylmethionine Decarboxylase
**SAMeS** - S-Adenosylmethionine Synthase
**SARDH** - Sarcosine Dehydrogenase
**SAT** - Serotonin N-Acetyltransferase
**SCOT** - Succinyl-CoA:3-ketoacid CoA Transferase
**SCS** - Succinyl-CoA Synthetase
**SDH** - Succinate Dehydrogenase
**Se** - Selenium
**Ser** - Serine
**SGLT** - Serine-Glyoxylate Transaminase
**SHMT** - Serine Hydroxymethyltransferase
**Si** - Silicon
**SLC** - Solute Carrier
**SPDS** - Spermidine Synthase
**SPOX** - Spermine Oxidase
**SPS** - Spermine Synthase
**SQOR** - Sulfide Quinone Oxidoreductase
**SR** - Sepiapterin Reductase
**SSAL** - Succinic Semialdehyde
**SSAT1** - Spermidine/Spermine-N1-Acetyltransferase
**Succ** - Succinate
**SULTs** - Sulfotransferases
**SUOX** - Sulfite Oxidase
**T3** - Triiodothyronine
**TA** - Tyrosinase
**TALDO1** - Transaldolase 1
**TAT** - Tyrosine Aminotransferase
**TDC** - Tyrosine Decarboxylase
**TGF** - Transforming Growth Factor
**TGT** - tRNA Guanine Transglycosylase
**TH** - Tyrosine Hydroxylase
**ThDP** - Thiamine Diphosphate
**THF** - Tetrahydrofolate
**THL** - Thiolase
**THP** - Tetrahydropapaveroline
**TKT** - Transketolase
**TMLH** - Trimethyllysine Hydroxylase
**TNF** - Tumour Necrosis Factor
**TPH** - Tryptophan Hydroxylase
**TPI** - Triose Phosphate Isomerase
**TPP** - Thiamine Pyrophosphate
**TPQ** - Topaquinone
**TS** - Thymidylate Synthase
**TST** - Thiosulfate Sulfurtransferase
**UCK** - Uridine-Cytidine Kinase
**UDP** - Uridine Diphosphate
**UGPase** - UDP-Glucose Pyrophosphorylase
**UGAPase** - UDP-GlcNAc Pyrophosphorylase
**UMP** - Uridine Monophosphate
**UPP** - Uridine Phosphorylase
**UROC** - Urocanase
**UTP** - Uridine Triphosphate
**V** - Vanadium
**Vit C** - Ascorbic Acid
**Vit E** - Tocopherols, Tocotrienols
**VMA** - Vanillylmandelic Acid
**VMAT** - Vesicular Monoamine Transporter
**VNN** - Vanin-1 (Pantetheinase)
**XO** - Xanthine Oxidase
**Xu5P** - Xylulose-5-Phosphate
**Zn** - Zinc

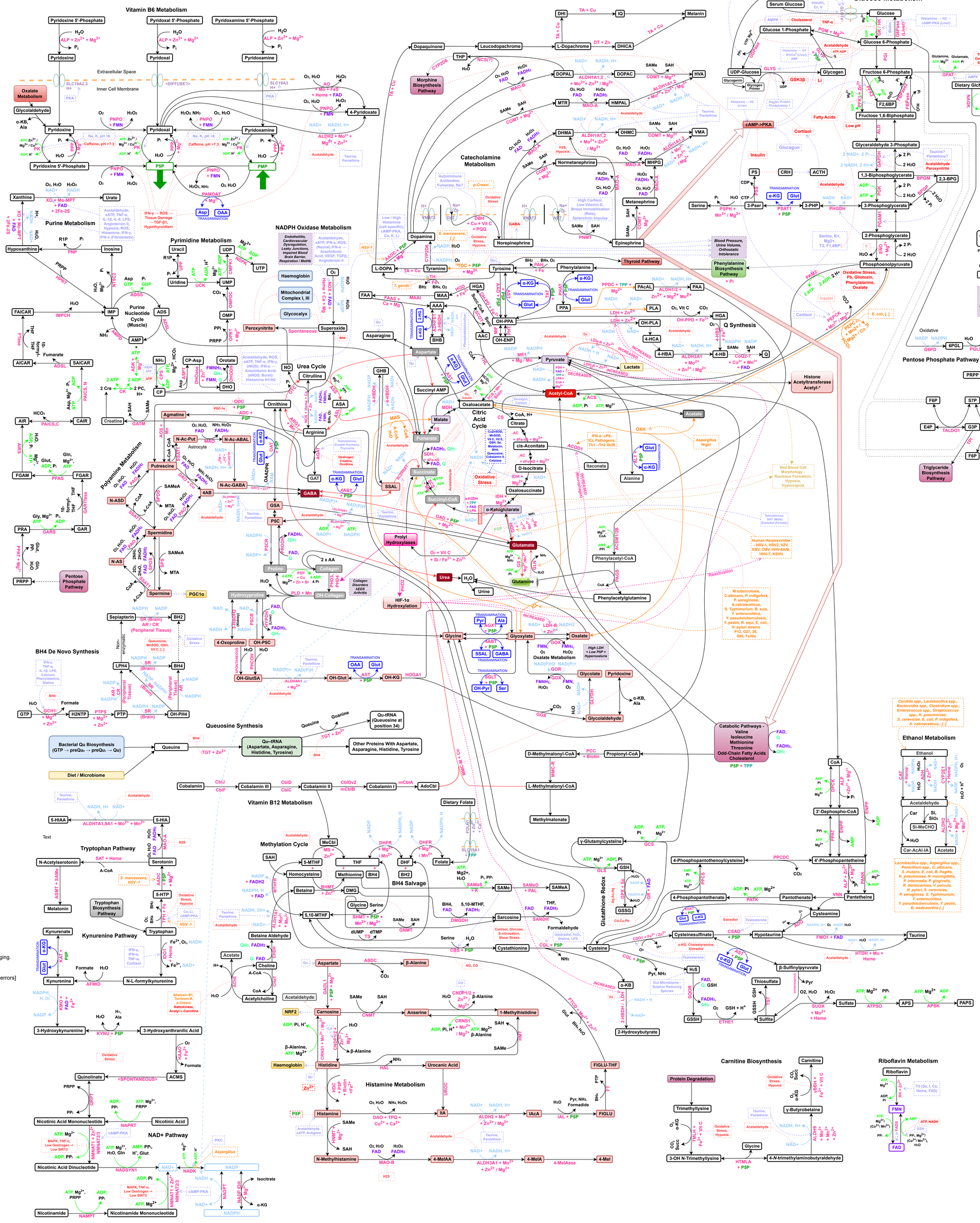


**Figure 1.Pathway Diagram:** The role of mitochondrial dysfunction in chronic disease and aging.

## ME/CFS: Correcting Chronic Mitochondrial Dysfunction

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**COLOUR KEY (Labels)**

ATP, ADP, AMP, GTP, GDP
TPP
FAD, FMN
NAD+, NADH, NADP, NADPH
P5P
Q, $QH_2$
REACTION
TRANSAMINATION
TRANSPORTERS
MICROBIAL / PATHOGENIC
PROMOTER
INHIBITOR
(Others - Illustrative)

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