What is claimed is:

1. A biologically active composition of matter comprising a first D-biotin conjugated to a water-soluble, cell-permeable, mitochondria-targeted peptide sequence to form a biotinylated polypeptide, wherein the first D-biotin is conjugated to an ε-amine of a C-terminal lysine residue of the mitochondria-targeted peptide sequence via an amide bond, wherein the mitochondria-targeted peptide sequence:

    comprises a minimum of four amino acids and a maximum of six amino acids; and

    has a general alternating aromatic-cationic motif.

2. The composition of claim 1, wherein the mitochondria-targeted peptide sequence is selected from the polypeptide group consisting of:

    D-Arg-L-Tyr-D-Arg-L-Phe-L-Lys-NH_2 ;

    D-Trp-D-Arg-D-Trp-D-Lys-OH ;

    L-Trp-L-Arg-L-Trp-L-Lys-NH_2 (SEQ ID NO:1);

    D-Trp-D-Arg-D-Trp-D-Lys-NH_2 ; and

    L-Trp-L-Arg-L-Trp-L-Lys-OH (SEQ ID NO:2).

3. The composition of claim 1, wherein a second D-biotin is conjugated to an N-terminus α-amine of the mitochondria-targeted peptide sequence.

4. The composition of claim 1, wherein the mitochondria-targeted peptide sequence is :

    D-Biotin-D-Trp-D-Arg-D-Trp-D-Lys-OH.

5. The composition of claim 1, wherein the biotinylated polypeptide is selected from the group consisting of:

    D-Trp-D-Arg-D-Trp-D-Lys(biotinyl)-OH ;

    L-Trp-L-Arg-L-Trp-L-Lys(biotinyl)-NH_2 ; and

    D-Arg-L-Tyr-D-Arg-L-Phe-L-Lys(biotinyl)-NH_2 .

6. The composition of claim 1, wherein the biotinylated polypeptide is selected from the group consisting of:

D-Biotin-L-Trp-L-Arg-L-Trp-L-Lys(biotinyl)-NH_2 ; and

D-Biotin-D-Arg-L-Tyr-D-Arg-L-Phe-L-Lys(biotinyl)-NH_2 .

7. A composition of matter, comprising:

a therapeutically effective formulation comprising:

one or more biologically active, water-soluble, cell-permeable, mitochondria-targeted compounds selected from a biotinylated polypeptide group; and

a pharmaceutically acceptable carrier for each of the one or more biologically active, water-soluble, cell-permeable, mitochondria-targeted compounds;

wherein each biologically active, water-soluble, cell-permeable, mitochondria-targeted compound in the biotinylated polypeptide group is defined by:

a plurality of amino acids arranged with a general alternating aromatic-cationic motif;

a minimum of four amino acids and a maximum of six amino acids;

a first D-biotin conjugated via an amide bond to an ε-amine of a lysine residue located at the C-terminus of that biotinylated polypeptide.

8. The composition of claim 7, wherein:

the biotinylated polypeptide group consists of:

D-Trp-D-Arg-D-Trp-D-Lys(biotinyl)-OH ;

L-Trp-L-Arg-L-Trp-L-Lys(biotinyl)-NH_2 ;

D-Arg-L-Tyr-D-Arg-L-Phe-L-Lys(biotinyl)-NH_2 ;

D-Biotin-L-Trp-L-Arg-L-Trp-L-Lys(biotinyl)-NH_2 ; and

D-Biotin-D-Arg-L-Tyr-D-Arg-L-Phe-L-Lys(biotinyl)-NH_2 .

9. The composition of claim 7, further comprising:

one or more vitamins selected from the vitamin group consisting of:

vitamin B1 (thiamine);

vitamin B2 (riboflavin);

vitamin B3 (niacin, niacinamide);

vitamin B5 (pantothenic acid);

vitamin B6 (pyridoxine);

vitamin B7 (biotin);

vitamin B9 (folate);

vitamin B12 (cyanocobalamine); and

vitamin C (ascorbic acid).

10. The composition of claim 7, further comprising:

one or more metabolic supplements selected from the metabolic supplement group consisting of:

pyruvate;

carnitine;

acetylcarnitine;

creatine;

α-ketoglutarate;

α-lipoic acid;

coenzyme Q;

nicotinamide riboside; and

nicotinamide mononucleotide.

11. The composition of claim 7, further comprising:

one or more amino acids selected from the amino acid group consisting of:

leucine;

isoleucine;

valine;

glutamine;

serine;

arginine;

methionine;

tryptophan;

glycine;

trimethylglycine;

and

Taurine.