

Supplementary Figure 3: DNA-PKcs COBALT Metazoa Vertebrate Invertebrate

Supplementary Figure 3. Results of COBALT alignment of DNA-PKcs sequences from selected vertebrate and invertebrate species. DNA-PKcs amino acid sequences from the organisms listed below were analyzed by COBALT using the default settings (conservation setting 2). For additional information on sequences and phyla please see Supplementary Table 1. For graphical image, please see Figure 4A.

TERMITE	1	MM	GSELI---GFVEVINSICISGNHLNKYIEAKSNISNIISYfeDKRRKRTDLG---AFTVLFDDKKTGILQFIQKALK	71
SHRIMP	1	MA	[5]EELDL---LLGKLSQSPGPNQGDDPAADKVIDIAELL--AVDLTPAQY-DLYISQVLG-EKGIITFGRSVSK	74
SCORPION	1	MN	[1]ITNSL-HENILKLNDFIKY--QKDEGHSSIVIKDISEI--CLRGLTSEKDrSYVCSLILRKEDGFLHFLAEAVN	73
ALVINELLA	1	ME	-----NLGCC-----CALLFSKETGITNFKKKVQ	27
CAPITELLA	1	MA	--RAL-QEQLAGLVSDTRGQPGVNVARISHESIGNIGAI--CLNDVNASDV-DLAYSVIFNHETGLIKFLKKIQQ	71
SPONGE	1	ME	-----SRIEHLWESLHSSSPQRYSY-AVEVASDLYSL--CVEQITESEL-AYSSSVLFPNDGILKFLHDVVT	66
OYSTER	1	MA	AS---LLEDNLRSLN-ECLTTADNSSKQADSIIVADISQI--CINESTDKDI-DLCCSVLFDKRRGLVFLSETVT	71
SNAIL	1	MA	AT---L-EETLRSLH-D---QSGASAYNLANGLIADIRQI--CLHEISEKDR-DYCCSALFDKDIIGLIAFLQKVA	67
TRICHOPLAX	1	MA	--SNL-SQLLIDLHALLNL-QSLHRGSNACDIASDIIVL--CLQTASDAEK-AYCSALFSGQYGVVTFLRKSLG	70
SEA_ANEMONE	1	MT	--DAI--SSRLQLNELVAE-ESPLRQGESABIARDLRAH--CSQLRDESELGARCSSLILFDKDTGIIRFLHKTIA	71
PRIPAPULA	1	MA	RTVRI-EDHVQTLLESLPSDDREADPETAHSAVADLAHK--CLQDISKRDV-DLTCVSLFSEDRGVLIFLRRRAIP	73
ESHARK	1	MA	[4]AAADT-LSAFSKLHLLSLSDVKSAAAEHSASVGSISRDrCS-SSSDSQL-ALQSSMVFSKDTGLLVFLRKSRLR	78
STERLET	1	MA	[7]GAGGI-QGNLHKLHSFLNADAKSAAVESHNLIGNLQGE--CMVSKNENEL-VLQTSLIFSKENGLLAFVRKSLN	80
COELACANTH	1	MA	[7]AVEGV-SGYLLKIHSSLTVDTKSAAEISNIFGNLRQE--CLVTSDENEL-ALHISLIFSKETGILLIFLRKSLG	80
HUMAN	1	MA	[1]SGAGV-RCSSLRLQETLSAADRCGAALAGHQLIRGLQGE--CVLSSSPAVL-ALQTSLVFSRDFGLLVFVRKSLN	74
CAECILIAN	1	MS	[7]SAVGV-QGSLRLHSLSSKDPGLEAPVAQSLIRSLGEE--CVTSSGDSVL-ALQTSLIFSKHEGLLAFIHKSLG	80
PLATYPUS	1	MA	[4]---GP-QGSLRLRQFLAEADAGVSAVAAYQILRGLQGE--CVLSAGPAVQ-ALHSTLVFSEKFGPLVPIRKSRLR	74
CANARY	1	MA	---GV-QQCLLQLHRCLQPGDAGGSALHGYSLLRSLAET--CLASLASGEQ-ALHLSLVFSQYGLLVFIRHSLT	70
OSTRICH	1	MC	---SE-R-----KDVQAD--CVFALPA---ALHISLVFSQYGLLVFIRHSLG	41
TURTLE	1	MA	[6]GGGGI-QGSLHLQSCALQDPDPGTAALRGYHLIRGVGEA--CVTSTGDCGAR-ALQTSLVFSKDNGLLVFVRKSLN	79
ALLIGATOR	1	MA	[5]-----VIRTGDSAQ-ALQSSLVFSKDNGLLVFIRKSLN	39
SOFTCORAL	1	MT	--EVI-DRYLNQLNSCLKT-LSSSRGREAADICRDLRLY--CIENINETQL-AYCSLFLNQDGLLITFVKAIVQ	70
STONYCORAL	1	MS	--DLL-NRYLPHLHSLPDL-DAPHCHGLDASNTVVDLGSF--CLENVSSSEQ-AYSSLFLSGETSIVSFLRKKVIT	70
ACORN_WORM	1	MP	SS-EL-QSKLAELELLEDETPSQHTVEKCNLIGEIQLI--CLRTTSENEL-AYHCSVVFHKTGILLFLKKTIT	72
LANCELET	1	MA	GSGL-EARLSELHALLESDHGHGAVEAHLNVDIAQI--CLRHTAERDV-AYCSVLFQESTGITAFLRKTVT	73
SEA_URCHIN	1	MA	AA-EL-QRHLAELHEVIDSGGTAHPETAQDLVVDIAQL--CLNQIRENEL-AFCRSSELPQKGTGITIFLQKAVS	72
STARFISH	1	MA	TA-DL-PVKLSELNGLISTKSGLHVAKAQLLVLDLGHLL--CLRQISENEL-AYCSQFLNKDNGLLVFLNKAIP	72
TERMITE	72		QDAFTEAIKESFVLLKQLIDVFKERMSC	144
SHRIMP	75		DQSFVEAKKSTLDVLTLLDKEAQKINK	150
SCORPION	74		TPSLKDSLIEALQFLNLFNIGNKVVQ	149
ALVINELLA	28		KDEFDLCKVDALKMMLALVVKYDKLLS	103
CAPITELLA	72		NDEFEGCKCELELLKTFISKPPGVHP	147
SPONGE	67		LEEFASCKEELKLLSNFVKNLSRRVLS	142
OYSTER	72		KEEFQTCQKLELFLSEFVQRIGKKIIP	147
SNAIL	68		KDEFQSTKTNLLDIFGDFLQKVGKLLP	143
TRICHOPLAX	71		LDDLDKREDLLKLIATYMEKIGGKISP	146
SEA_ANEMONE	72		NQEFVECKTELKFLQSYLQGLNTRVNP	147
PRIPAPULA	74		LDEFKLAKEELKQLLHSHFNKQGRILT	149
ESHARK	79		FEFPRDSRELVKLLSEVVERIGEAVGR	154
STERLET	81		IEDFRDREELKLLTFLDRIAHKVN[4]	159
COELACANTH	81		SEFPRDNEELKFLFAVFKIGQKLN	151
HUMAN	75		SIEFRECREEILKFLCIFLEKMGQKIAP	150
CAECILIAN	81		IEEFPRDREELKFLCIFLEKMGQKIVP	156
PLATYPUS	75		IEEFPRDREELKFLCIFLEKMGQKIEP	150
CANARY	71		IEEFPRDREELKFLCFMEKVGDKIHP	146
OSTRICH	42		IEEFPRDREELKFLCFMEKVGDKIHP	117
TURTLE	80		MEEFPRDREELKFLCFMEKVGDKIHP	155
ALLIGATOR	40		IEEFPRDREELKFLCFMEKVGDKIHP	115
SOFTCORAL	71		LDEFQAKIEELKFLQSYVMKMGKINP	146
STONYCORAL	71		LDEFQAKIEELKFLQSYVMKMGKINP	146
ACORN_WORM	73		IDQYVSSKERLEFVYVFMIRADKKIVT	148
LANCELET	74		LQDYLPKAVTEFLSFLAFLEKIGRKIVP	149
SEA_URCHIN	73		KDEYGGSKVQLEFLFGFVQKAKELVLD	149
STARFISH	73		KDELKGSQEQLLEFLHAPLKLKAGSRLLA	148
TERMITE	145		ELFDKLNIPFKSNKsNTMPAKVQKHLHLGLIIVHKYPECLRPe-ETRLLLRILYSELEMQ	219
SHRIMP	151		QFIERLCIDIRSAK---GSTVLQHQLQTLGMLMYSYPQNLRHq--SPILIKIFKQGLVKH	218
SCORPION	150		KIVNKIIEYL-AQASKIIPTPVKQAYYLLGSSRHYPDQMCLc--SERLLNWLKDLKPH	222
ALVINELLA	104		GIAEKLFYGLD--VHsSRHPSVQQRMYQLLGVIAEMYPPELMVR--HADRLVNVYVTTIKQ	176
CAPITELLA	148		GMIERLFKEL--IKsPKPAAVKAHIFHLLGVIAELFPEKMRVg--SDKLLNLYMTTLKQE	220
SPONGE	143		KIADKFFQAA-LLP-TKHSATIRGGYHLLGVLCWFFPEHLVKi--SSRLIDIYMSNLKSE[1]	216
OYSTER	148		KMINKFFMEL-TKSvSKLPASVKESIVYLLGLLAEIYPEHMTQ--YAGKLVDIYLRALKAE	221
SNAIL	144		NLVEKLFREL--TKT-SKLVPTVKGNIYFLLGVIAEVYPEDITQ--DSDRLVGLYVSAKAE	216
TRICHOPLAX	147		KLVDKYSAC-QQP-TKSYSTVKSVMYLLGIAIEKFPPEYIMP--HAQOLLTIYINLLKSO	219
SEA_ANEMONE	148		KLIDRYFKAC-LQS-SKQSTVRFWLYTILGVFAEVPPEHMLG--NADRLISYINLNSE[1]	221
PRIPAPULA	150		KLIDRYFNEL-TQS-SRLTSTVKGYYHLLGVIAESYPELMVA--YADKLIISYVNELKNO	222
ESHARK	155		EIPNKFYGLD-SQK-SKFPDVLKVEYELLLGVIAEVQPTMELH--NSEKLFRAFLNLRVSG	227
STERLET	160		DMFNKFYGLD-AQK-SKIPDVLKVEYELLLGVIEVQPSDMLN--NSEKLYRAYLSELKSO	232
COELACANTH	152		EMFNKFYGLD-AQR-SKLPDVLKVEYELLLGVIEVQPSMELH--NSEKLFRAFLGELKTO	234
HUMAN	151		ELFSKFYGLD-ALK-KKIPDVLKVEYELLLGVIEVQPSMELN--NAENLFRAYLSELKTO	223
CAECILIAN	157		EIPNKFYSEL-GVK-SKVPDVLKVEYELLLGVIEVQPSDMLD--NSEKLFRAFLGELKTO	229
PLATYPUS	151		GINVEKLYEL-ALK-TKIIDTVLEKIEYELLLGVIEVQPSMELC--NSEKLFRAFLGELKTO	223
CANARY	147		EIPNKFYSEL-AAR-SKIPDVLKVEYELLLGVIEVQPSDMLN--NSEKLFRAFLRELKTO	219
OSTRICH	118		EIPNKFYSEL-ATR-SKVPDVLKVEYELLLGVIEVQPSDMLN--NSEKLFRAFLGELKTO	190
TURTLE	156		EIPNKFYSEL-AAR-SKVPDVLKVEYELLLGVIEVQPSDMLD--NSEKLFRAFLGELKTO	228
ALLIGATOR	116		EIPNKFYSEL-AGK-SRVPDVLKVEYELLLGVIEVQPSDMLD--NSEKLFRAFLGELKTO	188
SOFTCORAL	147		NIVEKLYEL-SQS-TKKKSSVSYGIYSLLGVIAEYPEYIMP--KADRLVQIYVGLKAE	218
STONYCORAL	147		KIPDKYFAGL-IQP-VKHSSTVYKWLFSLLGIAKVPPECVIS--HSDHLVKNYVSLKLE[6]	225
ACORN_WORM	149		KLIDKYSQ-LMQP-SKLAATVVKHGIVYHLLGVFAQYVPELMTK--YSDRLLVNVMKALKSO	221
LANCELET	150		DMVDRMFLLEL-TMK-SQTTATVKSAGSLLGVISEVYVPELMTKdHPDRLLKVIYSMLKBEQ	224
SEA_URCHIN	150		AMKLFKFFGEL-GQP-SKLSQSVKLGQYTLGAFGEYIYPLMMH--YSDRLFNVLVSTLQKQ	222
STARFISH	149		KMLLYFQEQL-MQP-SKLSQTVKQYICLLGVIAEYIYVPLMSG--YSERLLSVYIATLNQO	221

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TERMITE	220	LNGLTEFLYVFPKLPQE--KEARRIYDCVTAVARK [2]----	EMRVAPRCALGLIQAHGGLAKFLYDEYKFw----	HEFL	289
SHRIMP	219	LRGLALYLHHPPEIGDDPQLFTELYKHIIKVLNP	DLNLPRRDAQRAALELIHTHGAKFSQQLFEDCTQ----	VFQWF	292
SCORPION	223	LQGLNEFMYPPLQDEDTKAYQLFKFIRIILSK [1]--	DVKTYDMAKASLTLSSHASLLAQFLYEDSMN----	YKII	295
ALVINELLA	177	LRGLCHLLVHFTQSAEEAAHSCDIKYKCAAIK [2]	NEKLSKYEMAESGLKLLAKHASQFNKFLDEYKI----	MYERL	252
CAPITELLA	221	LQGLTHFMVNFQSADEGAEHAYSIIKYCVKTMDO	NIKKRYEMPKASLGLMAKHASQMSDYLLDDFKD----	LYETL	294
SPONGE	217	LYGLTAYLNNFSQSAEGSGVYQDIYKYTRMAIDP [1]	ANLTRYEVPRAGLSLSRHAQFREYLKDSH----	MYESL	290
OYSTER	222	LEGLASCLVNFTE--DEDSQNSYETFKFARMADP	DINTRYDVPFRAGLKLFRSRSQAQFSQLADDYQG----	MYQKL	293
SNAIL	217	LQGLTAYLVNFQSSDEGSSHSYEIFNYARMAIDH	KVEFSKYDVPKAGLQLFARHAGQFSQFLVDDYEN----	MYTKL	290
TRICHOPLAX	220	LRGLTAYLVNFQSSVEESKYAADIYKARLAIDP	KVELPRYDLPKAGLNLAKHAAQFCDYISREAEA----	LYEVI	293
SEA ANEMONE	222	LKGLSSYLNVFQSAEESKPFARDIYEFTRMAIDV	QGLTQRYDVPFRAGLNLSSRHAGQFQEYICTEHNVsliVPAI		298
PRIAPULA	223	LRGLTCYLNFTFSQSADEGSGYARDVYDCVMRCTGQ [1]	LSEIRRYDVAKSALWLLAKHAAQLDRFLLDYKA----	VYSC L	297
ESHARK	228	LRGLTALMINFTKSMEDPKASKDIFDYALKAINP	QIDLKRYAVPLAGLRLFTLHSSQFGTCLMDNYRT----	VFEKM	301
STERLET	233	LRGLTALMINFTKSMEDPKSKEIFDFALKAISP	QTEFKRYAVPLAGLRLFAKHAGQFSCLMDNYRS----	LYEVM	306
COELACANTH	225	LRGLTALMINFTKSVDEDPKTSKEIFDYAVMAISP	QVDLKRYAVPLAGLRFALHAGQFNCTCLMDNYRS----	LFEFM	298
HUMAN	224	LKGLSSLLCNFTKSMEDDPQTSREIFNFVLKAIRP	QIDLKRYAVPSAGLRLFLALHASQFSTCLLDNYVS----	LFEVL	297
CAECILIAN	230	LRGLTALMINFTKSMEDDPKVSKEIFDYSVKAISP	QVELKRYAVPLAGLHMLAIHASQFSGCLMDNYRS----	LYEVM	303
PLATYBUS	224	LKGLSALMCFNFTKSMEDDPQTSKEIFDFAVKAISP	QVDLKRYAVPLAGLHLFTVHASQFGTALLLDNYVY----	LFEVM	297
STONYCORAL	226	LRGLTALMINFTKSMEDDPQTAKEIFDFAMKAISP	QVDQKRYAVPLAGLQLFWHSAQFGLLDLDNYVS----	LYEVM	293
CANARY	220	LRGLTALMINFTKSMEDDPQTSKEIFDFAMKAISP	QIDQKRYAVPLAGLQLFGRHAAQFGTFLLDSDYVS----	LFEFM	264
OSTRICH	191	LRGLTALMINFTKSMEDDPQTSKEIFDFAMKAISP	QVDLKRYAVPLAGLHLFMSHAAQFGTFLLDNYIS----	LFEVL	302
TURTLE	229	LKGLTALMINFTKSMEDDPKTSKEIFDFAVKAISP	QVDLKRYAVPLAGLRFGLHAAQFGTCLLDNYVM----	LFEVM	262
ALLIGATOR	189	LKGLTALMINFTKSMEDDPKTSKEIFDFAVKAISP	KINRYAVDVPFRAGLFLARHAGQFKEYLTKDYES----	VYNTL	292
SOFTCORAL	219	IRGLDSTLVNFQSSVNEGSIYAKNIYSFLRSAIDS	QVLSRYEVKAGLRLFAKHSAGQFKEYIAKDYEV----	MYGDL	299
STONYCORAL	226	LRGLTALMINFTKSMEDDPKTSKEIFDFAMKAISP	STQLLRYGVPKAGLWLLAKHAAQFKNYLLDDHEE----	MYDKL	295
ACORN WORM	222	LRGLTALMINFTKSMEDDPKTSKEIFDFAMKAISP	QVEMARYDVPKAGLWLLAKHAAQFNEYLMDYED----	MYRKL	298
LANCELET	225	LRGLTALMINFTKSMEDDPKTSKEIFDFAMKAISP	SGTKPRYEIPKAGLNLIRRHADQFNEYLKRDHEM----	VYNRL	300
SEA URCHIN	223	LMGLSHLLVNFQSSVEENSKHKDIYQVYTMVSDP [4]	TVDHTRYELNKAGLNFMAKHSAGQFPLYSDHQD----	LHEAF	295
STARFISH	222	LRGLTALMINFTKSMEDDPKTSKEIFDFAMKAISP			
TERMITE	290	LKWINSACED--HKAGVSALDVFYVQVASILKDN--TSETG----	HHVFLYFINFFKNKMLSSSTSSYDMKLVKAFGLFA		362
SHRIMP	293	VKWCGRNRDDHKAALPAMDTFIVVIANMLELQ--AMED--	DKRGVKIFKYLLEQYKNKMLTSESTSK--LSLAVKGYGLLS		368
SCORPION	296	EIWTNHSNREVRSLGYNALDAVFKQISD--MLEQ--NYE	DS--CKAEI--FKPFIEKQMLIKCSE--NIRRVSTAIRGFGYFA		329
ALVINELLA	253	AFWCHHNRVMMHGLFSAMEAFFKQISAHVLL--ANEG--	RKERSIFMFMEEFRKIMDNPESSSKEISLAIHGCGYFA		368
CAPITELLA	295	SYWTHNNNREMAHIGMLALEDFLVQISSALVTK--	VKEG--NRKEGAVFKFPIQKFRDMDNNSGSKETAIAIKGCGYFA		371
SPONGE	291	SSWSNHNKMKCRVAVNAIGSFFREVSTQISDP--SIS--	RELGISNYKFKMCKFRSLMNDPDIHNRLLSIAVKGYGHPA		366
OYSTER	294	KSWSKHNNRELLHLGTAAMEAFLTQISEVLVTK--AREG--	KKEAAMFKFVTRFKIEMENSSASAKEMSLAIRGYGLLA		369
SNAIL	291	QAWSKHQNRDVLHGHVAAAMDALRQIAEAITEK--AKRG--	IKEGGIFKPFVQVFTTMQNSSASSKEVSMVAVRGYGLFA		366
TRICHOPLAX	294	YRWCHHNRVMMHGLFSAMEAFFKQISAHVLL--ANEG--	NINIFKFLKPKFRSIISSGSSDAKELAIKIRGYGYP		367
SEA ANEMONE	298	YRWCHHNRVMMHGLFSAMEAFFKQISAHVLL--ANEG--	FIQRFRAIIDSSTTQMSIAIRGYGYP		371
PRIAPULA	299	RSWSNHNKMKCRVAVNAIGSFFREVSTQISDP--SIS--	RQRDTIVFTVFREFTIIE--AGTDRDVAIAVRYGGSFA		373
ESHARK	302	KKSCGHTNSEMKKASYSALESFLKQVAI--QVAE--NAHL--	HKDKL--EYIMQFYDIIRTPESMKELSAIRGYGLFA		374
STERLET	307	SKWCGHNTNEMKKAGYHALEAFLKQVAL--LVAE--NAEL--	HKSKL--EYFMRQFYTVIRTLDSSTKELSAIRGYGLFA		379
COELACANTH	299	YRWCHHNRVMMHGLFSAMEAFFKQISAHVLL--ANEG--	HKNKL--EYFMKQFYGIIRTLDSNNKELSAIRGYGLFA		371
HUMAN	298	LKWCAGHTNDELKKAALSALESFLKQVSN--MVAK--NAEM--	HKNKL--EYFMEQFYGIIRNVDSNNKELSAIRGYGLFA		370
CAECILIAN	304	SKWCGHNTNDELKKAAGHSALESFLKQIAS--IVTH--DAET--	HKSKL--EYFMQFYRIIRKLDSSNNKELSAIRGYGLFA		376
PLATYBUS	298	AKWCGHNTNDELKKAAGHSALESFLKQIAS--IVTH--DAET--	HKSKL--EYFMEQFYRIIRKIDSTNNKELSAIRGYGLFA		370
CANARY	294	KWCGHNTNDELKKAAGHSALESFLKQIAS--IVTH--DAET--	HKSKL--EYFMEQFYGIIRRMDSNNKELSAIRGYGLFA		366
OSTRICH	265	SKWCGHNTNDELKKAAGHSALESFLKQIAS--IVTH--DAET--	HKSKL--EYFMEQFYGIIRRMDSNNKELSAIRGYGLFA		337
TURTLE	303	SKWCGHNTNDELKKAAGHSALESFLKQIAS--IVTH--DAET--	HKSKL--EYFMEQFYDIIRKMDSSNNKELSAIRGYGLFA		375
ALLIGATOR	263	SKWCGHNTNDELKKAAGHSALESFLKQIAS--IVTH--DAET--	HKSKL--EYFMEQFYDIIRKMDSSNNKELSAIRGYGLFA		335
SOFTCORAL	293	FDWCKRKNKELRVKGFALAEFLKQVAECLVTE--DFETT	VECGDI--FKYFIKFRRIINSNESLREISIAIRGYGYP		369
STONYCORAL	300	YRWCHHNRVMMHGLFSAMEAFFKQISAHVLL--ANEG--	KSDLAMFMYFIKTFRRIIDSVLSDTRQMAIAVRYGYP		374
ACORN WORM	296	FSWCCHHNRVMMHGLFSAMEAFFKQISAHVLL--ANEG--	TKKDKR--NKT--TIFKAFIRKFRSIIIDNRESGTRICIAIKGYGLFA		372
LANCELET	299	YEWQHPNRDLKQAGYAALESFLKQISDMLVARHEKEN--	NKADLAVFKFPIREFTIITDTTEAGTREMIAVRYGYP		376
SEA URCHIN	301	KYWSHSHNSEMKNAGYDALQAFKVVSH--MLVE--RAKK--	RSDVAVLVKVFYKSFRTIDDASSSSKSLSTAIRGYGYP		377
STARFISH	296	NKWSAHNPAVKAVGFAAQEAFLLQIAEILV--E--RAAK--	DASDMAVFRFVVKFRDIIDNPQSDTRALSSAVRYGYP		372
TERMITE	363	APCRVYMPQDVLVYMFVVMQRAEQIYF	KEG--DISNADLQNLDPYIESLSSIMRQLSAVTNEQLVALQCLTVQLIEN		438
SHRIMP	369	GACRQFLSPVEVHFMFSQVLTAHQHAFY	-QsGDMLNENKLTNLPYSYIESLAIISNMVDVNSGILENVQQLSSALVEH		444
SCORPION	370	KVKCLYLTEKDVKYMNDVIKSEQHCL	NEE--KILDERITILPFLDLSLSSIVLQQLQEISESSLNLYEKLAVFQIQN		445
ALVINELLA	329	TPCRIFLSDQDVKFMFTEVMQRSEQMLI	VQA--EYLLDDRITSLPHFLALASIKELSEVDTLILLVEKLLILLVEH		404
CAPITELLA	372	APCKLYLTPKDVLFMFMNEMLRSEQLFL	-SGaEQNDDRIIGLHSLGALASIVEELDQFSETFLFSLERLVVLMQV		447
SPONGE	367	KPCRLYGSMEDLHFMFMGEMVQRSEQLFL [6]	-TSSsSVAPEERFLLPTFIEALANISKEIQNLDPVCSLSSQLSVLPHC		449
OYSTER	370	APCRREFLQKDVQFMFSEMITKSEQLYL	SSDKEDIEDKLYSLPSYLEALGNIRQLDHPETAYATSIERLMIILAEN		446
SNAIL	367	APCSIFLEPADVTFMFMSEMITKCEQEF	RTN--BPVHEKLSLDPYLHALASIKVVTKVSEVYALTLELRLVLLLEN		442
TRICHOPLAX	368	APCKTLKDKDVRFMFMDLLQRSEQLFF	--I--DVNVDKIQYLPSPLEAFASILNLDVNDTFFTRSEKLTIVLFPEN		441
SEA ANEMONE	372	KPKCLFMTAEDVDFMFMTEMMQRSEQLFF	RQS--EMQEDRVQPNFLALASIFIEELDDISDGLVLSLERLIVLFPES		447
PRIAPULA	374	TPCKLFLSEADVQYMFTEMMVRSRQIFH	-SGeEMIDSRMVELPPLLEALASIVTELDQVSEFLASLQVLVLLFGN		449
ESHARK	375	APCKA--VNSNDVDFMFIELIQRCKQMYL	TEA--DTEDDNVYQLPSFLDSIASVIFHLDKIPGVYTPVLERLIVVQIDS		449
STERLET	380	APCKA--VCLGDVDFMFIELIQRCKQMYL	TET--DTEDDNVYQLPSFLDSIASVIFHLDRIPEVYTPVLERLIVVQIDS		454
COELACANTH	372	APCKA--VCPEDVDFMFIELIQRCKQMYL	TET--DTEDDNVYQLPSFLDSIASVIFHLDRIPEVYTPVLERLIVVQIDS		446
HUMAN	371	GPCKV--INAKDVFDFMFIELIQRCKQMYL	TQT--DTGDDRVYQMPSPFLQSVASVLLYDTPVEVYTPVLEHLVVMQIDS		445
CAECILIAN	377	APCKV--INAKDVFDFMFIELIQRCKQMYL	TEA--ETEDDNYQLPHFLQSIASVIVHMSDIPVEVYTPVLERLIVVQIDS		451
PLATYBUS	371	APCKV--INPNDVDFMFIELIQRCKQMYL	TEA--ETIDHDLFQLPSFLQSIASVILHLDKIPGVYTPVLERLIVVQIDS		445
CANARY	367	SPCKA--IHPEDVDNMYVELLQRCKQMYL	TEA--ETIDHDLFQLPSFLQSIASVIFHLDKIPGVYTPVLEHLVVLQIDS		441
OSTRICH	338	APCKA--IRSKDVFDFMFIELIQRCKQMYL	TEA--ETVDDHIYQLPSFLQSIASVIFHLDKIPGVYTPVLERLIVVQIDS		412
TURTLE	376	APCKA--INSKDVFDFMFIELIQRCKQMYL	TEA--ETADEHYQLPSFLQSIASVIFHLDKIPGVYTPVLERLIVVQIDS		450
ALLIGATOR	336	APCKA--INSKDVFDFMFIELIQRCKQMYL	TEA--ETADDNVYQLPSFLQSIASVIFHLDKIPGVYTPVLEHLVVMQIDS		410
SOFTCORAL	370	KPKCLFLKDEDIKYMFTSIIQMSQMYF	NDS--ELKKEKLNLPSPLEALGFVIEEDIEPPAFSLFLERLIVVLEIK		445
STONYCORAL	375	KPKCLFMQADDVDFMFMSEMITKSEQLYL	SQS--DLSBDRQHLPPTLEALSSIEELDKISDSVFLACMERIVVLPDK		450
ACORN WORM	373	APCKLFLSEDDVDFMFMSEMITKSEQLYL	SON--ELVDETIPLHPSFLALACIVRELDVSDTFLSSLETMTVILMEN		448
LANCELET	377	APCKMFLSESDVDFMFMSEMITKSEQLYL	GTA--EMEDKVHLLPSFLALASIVQLDQSDMFPVTSLERLIVVLPEN		452
SEA URCHIN	378	APCKAFMKEADVDFMFMSEMITKSEQLYL	VQG--EERLSQLPTYLEALASIVGQLDVTSDTFLTSLEKLVVLPFGS		450
STARFISH	373	APCKLFMDDVDFMFMSEMITKSEQLYL	-QqGEVSDDKLNQLPNFLALASIMRQLDVLSDSFQAALERLIVVQVSS		448

Supplementary Figure 3: DNA-PKcs COBALT Metazoa Vertebrate Invertebrate

TERMITE	439	FPK--LPKPFHWAIRAITVTLSSLAESGGTfLEEFLSNVVYQGIIRSCKHQIAIDV-----ELQKq-----	498
SHRIMP	445	FPL--VSSFRFLAYRALFRFFVYVYKPGY-PHEPLHTFVYKAVLSCSHAPEVES--SPGEGSSWRG--KAGGGEW	517
SCORPION	446	FPY--LSPPYHFLCYNSLKLFLVAHVSXGPO-FKGLNKKIIVYQGIIRTCSPYVRFELI-----EAreENMSSGDLN	511
ALVINELLA	405	SPK--LPKPLHYIFVVFILKVCFSLTPKGSV-FRSPISRFFVYQALLRTRCSHPAVTTT--FDDDGQELDPe-----	469
CAPITELLA	448	LPR--LHVKLHNQCYIALIRLFLGLALKGSII-FKGFLEIRIYQSLIRSCSHPIVLESqEAKSENVDENVLk-----	515
SPONGE	450	YPF--LSSHVRYQGSVSLKLIMAVSS IPTS-FKQFLSHIVYQGVIRSCSLPVVIEA--VQGDSDAVVTA-----APL	517
OYSTER	447	FP--tIHQKQHFPSVSKSLLWVLTITMPKGEV-FSQVLSGFVQMLIRTCSSHPPLIET-----ED--MTESNQSE	510
SNAIL	443	IP--tIYRGHFHTCLRGILHLILVLSQKGSF-PNKVLSGFVYQGLIRTCSSHPVMA-----DE--NQEISTAE	506
TRICHOPLAX	442	FPY--VINELHSLCYKSLPELLLALHSGAA-LKNFLSRVVYQGLIRTCSSHPVYV-E-T--DSDLNISQ-----DSV	506
SEA ANEMONE	448	FPR--LSKSAKYLCHKALVKMLINISAKGSV-LKNFLSRVVYQGLIRTCSSHPVLL-D-E--GPDVVKQV-----GVV	512
PRIAPULA	450	VPLlrRESRLDHRACGAVRVLLALRSKRAT-QRSLVKKRVVQGLLSTCSHPVAMET----SSVFSQNA--DDVDDDFQ	521
ESHARK	450	FPL--YSARMQPICCRSIVKVFVALAGKGPV-LWNFIISTVVHQGLIRVCSKPVLLPG-EGTGRSESGLQ-----QQSASEVM	522
STERLET	455	FPQ--YSQRMQPVCCRSILKVFIALAGKGPV-LWSFISTVVHQGLIRVCSKPVVLTG-EEGQGGGGQ-----PVEKGGV	524
COELACANTH	447	FAQ--YSKMLHYTCCKSIVKVFALAGKGPV-LRNFISTVVHQGLIRVCSKPVVLTG-EGIKGGLQSEeEadPAPGEV	522
HUMAN	446	FPQ--YSKMLQVCCRAIVKVFALAAAGKGPV-LRNCISTVVHQGLIRVCSKPVVLTG-G---PESESE--DHRASGEV	514
CAECILIAN	452	FSQ--YSVKMQSVCCRSIIKVFALAGKGPV-LWNFIISTVVHQGLIRVCSKPVVLTG-EGSGKSGPGESE--EPPVAEEV	524
PLATYBUS	446	FPQ--YSVKMQACCAIVKIFLALAGKGPV-LWNFIISTVVHQGLIRVCSKPVVLTG-EAYGRDASESD--DSSAFGEV	518
CANARY	442	FPQ--YTEKMQPVCCRSIIKVFLSLXGKGPV-LWSFISTVVHQGLIRVCSKPVVLTG-DFSVKETSQTE--EAFEAGEV	514
OSTRICH	413	FPQ--YSKMLHYTCCKSIVKVFALAGKGPV-LRNFISTVVHQGLIRVCSKPVVLTG-EYFGKGLQSE--ESPAGEA	485
TURTLE	451	FPQ--YSVKMQSACCSIVKVFALAGKGPV-LWSFISTVVHQGLIRVCSKPVVLTG-EIFGKEVSKLE--ESTTAGEV	523
ALLIGATOR	411	FPR--YSKMQPVCCRSIVKVFALAGKGPV-LWNFIISTVVHQGLIRVCSKPVVLTG-EFDGKGASKSE--EPPAVGEV	483
SOFTCORAL	446	FPE--LGRGPFQICLAKMLKFLALTRRAS-LKFLSEIVYQGLIRTCSSHPVLL-D-E--GVDAME-----G-V	507
STONYCORAL	451	FAI--LNRGGKFLCCRALIRVFLHLSXKAT-LRNFISTVVHQGLIRTCSSHPVLL-K-EVNGESTIMEE-----REV	517
ACORN WORM	449	FP--fYKMLHYTCCKSIVKVFALAGKGPV-LRNFISTVVHQGLIRTCSSHPVLEG-----EMYDVSQ--DETSDELL	517
LANCELET	453	FP--LQKMLHLCQKAILKVLALVPKAT-LRNFISTVVHQGLIRTCSSHPVLEG-GTAEDELPVAGS--EGEGQQP	527
SEA URCHIN	451	YP--hQARSSQWTSASHAILQILIALSAGTS-LQKFLSRVVYQGLIRTCSSHPVLLS--GGDE----GE--EQRSDEME	518
STARFISH	449	YP--fVPNKYQYLSHQAILLVLIALSSKAT-LQKFLSRVVYQGLIRTCSSHPVLLS--SPSIDHPVLGN--DDQDTEAD	521
TERMITE	499	-QFHEENVFYKDYIPLWKELLSVNPFQKRSTSL-----TQTQLIVKVVYDKLVNIVLVLMKKLDLSTRKKTNiaL--	568
SHRIMP	518	KGLKNEVVTFSYIPLWALMPEKVANIKVSG-----MPATVMTEMSNFIYSEFISCIILEISEKLDLTYKQNELqqQ--	591
SCORPION	512	ELKNPREITSKSYSSLWENLLYIVRNKELNHIG-----ISLEDRHNLQLIYDEIISVVLTLKKLDLATTHSMQdseI--	585
ALVINELLA	470	--YRTRRTYKDYILNMWCKLLTCSRFEKELKHLG-----VGVVECAQFTEILYDELVSILRVLDRDLTCRDIVV-----	530
CAPITELLA	516	-----VDVYQDYLPWKKALLTAGLKLALGGYQY-----ITAEQHRVLAASAIYDELLSAMLKMIIRLDSNSTDS-----	587
SPONGE	518	ADSNDKVMSYLDVYVQLWQIQLIDYKYLKGMGMDFDL-----ELRQSIHQLVYSEFIQSLNLRKLDLFTTASTTEdgim-a	591
OYSTER	511	Q--TGTKTVTFKFDIELWDTLFSNPRIKESFVAD-----ISVVEVRLALTEAVYDELINSVRLMKLDLTSQSSTEvaqQ--	582
SNAIL	507	TDLTVKQITYKDYLEVWVSGLLESKIKDLIQDG-----IGFAERDQLTHAVYNELMQAILKVIISKLDLSTT-----Q--	574
TRICHOPLAX	507	ILETGPRISYKDYISLWKNLIQATEIKGL-----TLITTDREHIIVYQSLYNELHSLQRIILKLDLTSQQT--i	577
SEA ANEMONE	513	TGSRSDQVTKDYILPWRHLLDKTKFKMYLLFQSLSLSDIEKRESLHELVDLVCALIRIIEKLDLTSKHG--qQdl	589
PRIAPULA	522	-ERDRPNTIYIDYDMWRHLLGSDMKGLNELG-----VMSDRKALTCVYDEIVTSLMKIVGKLDLSTSKSTDPsqV--	594
ESHARK	523	WTGKWRVPSYKDYLDLFRSLLNCGMKKEFGLVD-TLGMINLPLQSLNRLLYDEFIKSIKILIEKLDLTSVEKQNO-----	595
STERLET	525	HTGKWKVPSYRDYLDLFRNLLCEDMKDTPGVDFADVRSSLSLNLRLLYDELIKSIKILIEKLDLTSVQKQA-----	598
COELACANTH	523	RTGKWKVPSYKDYLDLFRNLLCEDKRLQKALVDETFGVNPSLQSLNRLLYDELIKSIKILIEKLDLTSVQKQV-----	596
HUMAN	515	RTGKWKVPTKYDYLDLFRHLLSDQMDLADAEAFSVMSSSELNHLLYDEFKSVLKIIEKLDLTSVQKQV-----	588
CAECILIAN	525	RTGKWKVPTKYDYLDLFRSLLNCDKMKESIFSDVEF--SVNSPLQSLNRLLYDELIKSVLKIIEKLDLTSVQKQV-----	597
PLATYBUS	519	RVGRWKVPTKYDYLDLFRSLLNCDKMKESVDFANFLTEKAQLQSLRVLVYDELIKSVLKIIEKLDLTSVQKQV-----	588
CANARY	515	GTQRSKLPKYDYLDLFRSLLNCDKMKESVDFANFLTEKAQLQSLRVLVYDELIKSVLKIIEKLDLTSVQKQV-----	588
OSTRICH	486	GAGKWKVPTKYDYLDLFRSLLNCDKMKESVLEDENFLAANSALKLSRLLYDELLKSVLKIIEKLDLTSVQKQV-----	559
TURTLE	524	RTGKWKVPTKYDYLDLFRSLLNCDKMKESVLADETFLIANSPLLSLNLRLLYDELIKSIKILIEKLDLTSVQKQV-----	599
ALLIGATOR	484	RTGKWKVPTKYDYLDLFRSLLNCDKMKESVDFANFLTEKAQLQSLRVLVYDELIKSVLKIIEKLDLTSVQKQV-----	557
SOFTCORAL	508	TEFDVRIHSYKDYLEWCEFLDGGQYKD-----QSImpKVSILTQDIHRAIYDELIQAAILKVAHKLNLSSFRDVEtdqEdl	583
STONYCORAL	518	YEGSTPNTSLKDYLELWEYLLDKDKLKD-----ESLgKQLERKVMHGLVYDEMIRGILRIIIEKLDLSSKGSsaqeGdi	593
ACORN WORM	518	ID--ARKVSYKDYLDLWNLHLLDSSQLR-ITDYG-----LSPQDCKVLHNIYVDELIQAAIRILGKLDLSSNKDGGqlgnE-l	589
LANCELET	528	QQPPVWRVPSYRDYLDLWNLHLLDSSQLR-ITDYG-----VAVADRQAMHRLVYDELVTSLVKIIEKLDLTSKQVETgnEel	603
SEA URCHIN	519	IEQDSRRVSYKSPMDLWTRLLDSKFIKTSEAHG-----SSYAERLNIHTMIYNELIGGILKVLKLDLSSNKHNEeaS--	592
STARFISH	522	ILADARHTYKDYVVKLWASLLDSTHVKEVQAMG-----MNYADRRKIHTIYDELIQFISILKILSKLDLTSNK-DtTelq--	594
TERMITE	569	-----STSGGASEADI -PV--LDPESGLEANNRKFQVFINLVDLTRDVLMSVDCSQFEKWIQPFYKVISSESNK	636
SHRIMP	592	-----EEVSGSDE [2] -PA-tSDPVSGLKAKVPKDFQVYMNVSLEKVLPLQSEDLPHIPRLVWFFVQSSIQ	659
SCORPION	586	---KDSNLQFETSEL [2] -T-VSDPFYGLQSKPKDFRVMNIVDFCKDLFISKHNELEKWIIFGLEIIFQFNKN	657
ALVINELLA	538	--dkDQDQDFEASEDSV ISN-----KKQAPKPKDYIVFINLVDFCQDLPLSPVHKELFHKWLFTFGHQLIVHSTMH	605
CAPITELLA	581	-----ESQPS TSEPAL [2] -PS--SDPLRGLHAVCPEDFILLNLVLSRDLPLVPTQKQFSSVWVFPFHQLLQSSKL	650
SPONGE	592	N---EGEGGGGSGGDDP VIT--SDPVLGRQFVAVPKDFQFINLVDELAKKIVPSVLSLFTPWILTFSQEVVSLATRY	663
OYSTER	583	-----QEGPTSSNESE- [1] -V--sSDPLHGMQPKPKDFQFINLVDFCQDLPLSPVHKELFHKWLFTFGHQLIVHSTMH	651
SNAIL	575	-----RESESTGTSEEK [2] -ITqSGDPVHEIEANRPMDFQVFINLVDFCQDLPLSPVHKELFHKWLFTFGHQLIVHSTMH	642
TRICHOPLAX	578	E---EETQSS-----GT--SNPVAGLKNVVPKDFQVFINLVDFCQDLPLSPVHKELFHKWLFTFGHQLIVHSTMH	642
SEA ANEMONE	590	Q---VRDQPQE----- [3]ETT--SDPVALGRQFVAVPKDFQVFINLVDFCQDLPLSPVHKELFHKWLFTFGHQLIVHSTMH	658
PRIAPULA	595	-----HDGSGGASSESP [2] -YSggSDFADGLVPCRPKDFLVPFNLFVFTKDLSTNQALFRNRIYTYGHEVILLSTRW	667
ESHARK	596	R---EEEGSGDVSNNGV IPT--SDPAADLQFVAVPKDFQVFINLVDFCQDLPLSPVHKELFHKWLFTFGHQLIVHSTMH	667
STERLET	599	D---EQEGRS DASSML IPS--SDPAANLQFVAVPKDFQVFINLVDFCQDLPLSPVHKELFHKWLFTFGHQLIVHSTMH	670
COELACANTH	597	G---DQEGEDTPSSTII IPT--SDPAANLQFVAVPKDFQVFINLVDFCQDLPLSPVHKELFHKWLFTFGHQLIVHSTMH	668
HUMAN	589	G---EQEGEDAPGVMM IPT--SDPAANLQFVAVPKDFQVFINLVDFCQDLPLSPVHKELFHKWLFTFGHQLIVHSTMH	660
CAECILIAN	598	G---EQQDASDEDSALV IPT--SDPAANLQFVAVPKDFQVFINLVDFCQDLPLSPVHKELFHKWLFTFGHQLIVHSTMH	669
PLATYBUS	592	G---EK-DESEVSNLWV IPT--SDPVALHPSKPKDFQVFINLVDFCQDLPLSPVHKELFHKWLFTFGHQLIVHSTMH	662
CANARY	589	S---EQ-DGNAGDSALV GPS--SDPASNLQFVAVPKDFQVFINLVDFCQDLPLSPVHKELFHKWLFTFGHQLIVHSTMH	659
OSTRICH	560	N---EQ-DEDETDLSALV VPT--SDPASNLQFVAVPKDFQVFINLVDFCQDLPLSPVHKELFHKWLFTFGHQLIVHSTMH	630
TURTLE	598	S---EQ-DENEAGSDLV VPT--SDPASNLQFVAVPKDFQVFINLVDFCQDLPLSPVHKELFHKWLFTFGHQLIVHSTMH	668
ALLIGATOR	558	S---EQ-AESESGDVM IPT--SDPASNLQFVAVPKDFQVFINLVDFCQDLPLSPVHKELFHKWLFTFGHQLIVHSTMH	628
SOFTCORAL	584	Q---TEQSPSPDAPLTL [2] GGT--TDPISGLQFVAVPKDFQVFINLVDFCQDLPLSPVHKELFHKWLFTFGHQLIVHSTMH	657
STONYCORAL	594	L---GKSSASDVASAT [4] VSL--SDPVLGRQFVAVPKDFQVFINLVDFCQDLPLSPVHKELFHKWLFTFGHQLIVHSTMH	669
ACORN WORM	590	SadpEPGTSDDGRSSPVT [1] -LS--SDPSSGLTPKPKDFQVFINLVDFCQDLPLSPVHKELFHKWLFTFGHQLIVHSTMH	664
LANCELET	604	TadvS-GSQDGTTS-----DPAFAGLQAAPKDFQVFINLVDFCQDLPLSPVHKELFHKWLFTFGHQLIVHSTMH	670
SEA URCHIN	593	-----TSGGGLQFVAVPKDFQVFINLVDFCQDLPLSPVHKELFHKWLFTFGHQLIVHSTMH	661
STARFISH	595	-----DQVAVDSST [2] -AS--SDPLHGLHATPKPKDFQVFINLVDFCQDLPLSPVHKELFHKWLFTFGHQLIVHSTMH	663

Supplementary Figure 3: DNA-PKcs COBALT Metazoa Vertebrate Invertebrate

TERMITE	637	PLVSGFYKLLTVALQCLDRHLYFS-----D[2]DMLNQP	TEQKASYSLLCRFLOELLI	RLQQYKN	695	
SHRIMP	660	PLVSAHYNATTIVLTCRSRQTQFFS-----[3]D----	PEVETSIHLLMSYVRELLQ	RCRQYRD	713	
SCORPION	658	PYISGFYKLLTIVLCTTICKKTRFYQ-----HVKKLKT[2]EISMSE[1]-DCLIAFELFAKFSREVI[1]-LQQFKD			722	
ALVINELLA	606	PVVSFGYKLLSVMSTVASRIDYFQ-GIGKKIEREDAN[11]DMEIDS[6]SQREASFMFSKFTKEVLV		KLKQSKD	690	
CAPITELLA	651	PLVSGLYKMLTVMCQVASQISYFK-EMNRQLKIETSD[6]DEEFRT[2]AQEEACFMFLTFKFAKAVMT		RLRQYKD	726	
SPONGE	664	PLVSGFYKLLTIVLCSICNKTHFFD--VHDLSSGQGTGD[1]DVAMET[3]TDRQSCYFLFSSFIKEVVV		QMQQYKD	734	
OYSTER	652	PLVSGYKLLAVSMKIANKLNIFYQ-GMVSLL-----[11]DSDQKA[2]HQRATCFQLIQKFTKEVLV		RMKQYKD	725	
SNAIL	648	PLVSGFYKLLAVTMKIANKLYFK-DIAVE-----[11]DETGID[2]TEKHLTYLILKFFSEEVLV		RMKFFHD	721	
TRICHOPLAX	643	PLVSGFYKLLICMTIISLSYFE-DLNIEFTVTKCTI	NAAAEA[2]IDKYLCLLYKFKYKEVLV	RLKQYKD	712	
SEA ANEMONE	659	PVVSFGYKLLLEVCMKICKRFRFFQyEVTAD-----	--DMEI[3]SDCTNCFLLFRKFKIKEVLI	KMKQFKE	721	
PRIAPULA	668	PVVSGLYKLLTIVLCSICSSLYQFK-AMRKNVDSQL--[7]DSPDAV[2]AEILNCFTLFKKFSKEVLV		KLKMFGR	742	
ESHARK	668	PLVSGFYKLLSATMKIAKKINIFYK-GVSTNTWQOCHT	D-----	PEKACCFALFGKFGKEVTI	RMKQYKD	730
STERLET	671	PLVSGFYKLLSVMKIAKRIKYFQ-GVSPRSCKTSPS	D-----	PDKYACFALFAKFGKEVST[8]RMKQYKD	741	
COELACANTH	669	PLVSGFYKLLSVMKIAKRIKYFQ-GVSSKSKQNSL	D-----	PEKYACFALFAKFGKEVCA	RMKQYKD	731
HUMAN	661	PLISGFYKLLSITVRNAKKIKYFE-GVSPKSLKHSPE	D-----	PEKYSFCALFVKFGKEVAV	KMKQYKD	723
CAECILIAN	670	PLISGFYKLLSVMKNAKRIKYFE-GVSPKSHKCKPK	D-----	PERFACFALFAKFGKEVSA	KMKQYKD	732
PLATYBUS	663	PLISGFYKLLSIAIRNAKMKYFE-GVSPRSLLKXSE	D-----	PEKYSFCALFAKFGKEVAV	KMKQYKD	725
CANARY	660	PLISGFYKLLSVMKIAKRIKYFE-DISPRSLRRPCE	D-----	PEKSSCFALFVKFGKEVAA	KMKQYKD	722
OSTRICH	631	PLISGFYKLLSVMKIAKRIKYFE-GVSPKSLKCPSE	D-----	PEKSSCFALFVKFGKEVTA	KMKQYKD	693
TURTLE	669	PLISGFYKLLSVMKIAKRIKYFE-GVSPKSYKCPD	D-----	PEKSSCFALFAKFGKEVTA	KMKQYKD	731
ALLIGATOR	629	PLISGFYKLLSVMKIVKIKYFE-DVSPGTQKKYPE	D-----	PEKSSCFALFAKFGKEVAA	RMKQYKD	691
SOFTCORAL	658	PLVSGFYKLLDVMKISRKLDFYK-GMTLKDVTSTGCV	D-DMET[5]SDCRNCFLLFHKFAMEVVV	RMKQYKD	729	
STONYCORAL	670	PVVSFGYKLLLEVCMKCKECLSFYK-NIKAEPDLKNE	NLNLEI[3]SDCMKCFVLFHKFTKEIVV	RMQQYKD	740	
ACORN WORM	665	PLVSGFYKLLSVMCTISQNIQYFQ-GINENAKVAPR[8]KDMCTL	ADKVAAPHLKKFTKEVLI	RLKQYKD	740	
LANCELET	671	PLVSGFYKLLSVMCTICTKVKYFQ-DLDTK----LLS[8]EGRDRP	SEQQACFTLFRKFKYKEVLV	RLKQYKD	742	
SEA URCHIN	662	PLVSGFYKLLSVMCTISQNIQYFQ-EVNPVNTFRTEV[8]DDSES[12]SDKQACFTLFRKFKYKEVLI		RLKQYKD	749	
STARFISH	664	PLVSGFYKLLTVMCMNICTQIQFFK-CIKPDSLDS----[8]DLNFSS[7]SDRCICFTLFAKFSKEVLV		RLKQYKD	742	
TERMITE	696	DLQVACLETVIAAPVALVPLLPHPAVAFEVIFRVGRSMLPARLGLSALDKWYCTLPS	HLVTPLLMQVLPYLDPPFL	772		
SHRIMP	714	ELLASCLFLIHLPLCIVQEIFPQLVSPLOALQVGSVYPLAEVFCILALQLWTKLSLQ	EILSEHPHVLPLLLPYL	790		
SCORPION	723	ELLASCEVILSLPTEIVSEINILIPAVQISLQLGSLPLAMSCDALETWLYSLPS	ELLKEHYCKLLPSLNDYF	799		
ALVINELLA	691	DLASCLFLLSLPTEIVTELHVAIPALQALQIGYSYPLANAALDALDTSWQKIPD	SMMKFPYTDILQYLDPYL	767		
CAPITELLA	727	DLASCLGFLLALPHEI IALDVTTFVPALORSELEIGRYSPLARTSLNTLESWSKSLPP	DVMKPFYEQLLPYLDAYL	803		
SPONGE	735	DLASCLHLLVLVLPKEMVSDFKELIPAIKALRIGMGLYPLAKSVMEALEKWTLYIVE[4]DTLQCLVNEILPDLADYL		815		
OYSTER	726	DLAACLFTLITLTPKEIIAQQMSKIVPAIQLTFSVGLSYPLAEVGLDLSLVWWSQVLP	SVIRPFYQILPCLDSYL	802		
SNAIL	722	DLASCLTLLITLTPKEIIAQQMSKIVPAIQLTFSVGLSYPLAEVGLDLSLVWWSQVLP	EVLPAPHYANILPCLDSYL	798		
TRICHOPLAX	712	DLHVSCSLILALPYQLIQDDMALIIPAIKVMNIGLSYPLANAADALERSWSDLPQ	NIIGPYFSDILPCFDDYL	789		
SEA ANEMONE	723	ELLASCLFLLSLPTEIVADVAAVPALELTPFKLGLSYPLAQAGLALEEWNASLPG	DVLRRLRNILPCLDGYL	798		
PRIAPULA	743	DLVACLQVLMALPYEIVDVIPEIVPAVQVALKIGLSYPPMAHTLDALEMMWANLPA	DVMQPYKQILPHLDGYL	819		
ESHARK	731	ELLVSCLEFVILSLPHDIIMLDIKAYIPALQAFKGLSHTPLADAGLDALEDWSAHPK	HIIPHYKIDILPHLDGYL	807		
STERLET	742	ELLASCLFVILSLPHDIIMLDIKAYIPALQAFKGLSHTPLANTGLYALENWSQFIPK	YVMQPHYKIDILPYLDGFL	818		
COELACANTH	732	ELLASCLGFLLSLPTEIVELDVKAYIPALQAFKGLSHTPLADAGLDALEEWNSRIPK	WVLPQYKIDILPCLDGYL	808		
HUMAN	724	ELLASCLFVILSLPHDIIMLDIKAYIPALQAFKGLSHTPLAEVGLNALEEWESIYIDR	HVMQPYKIDILPCLDGYL	800		
CAECILIAN	733	ELLASCLFLLSLPHDIIMLDIKAYIPALQAFKGLSHTPLADAGLDALEDWSAYIPQ	YVIQPHYSIILPCLDGYL	809		
PLATYBUS	726	ELLASCLFVILSLPHDIIMLDIKAYIPALQAFKGLSHTPLADAGLDALEDWSIYIPR	HVIQPYKIDILPCLDSYL	802		
CANARY	723	ELLASCLFLLSLPHDIIMLDIKAYIPALQAFKGLSHTPLADAGLDALEDWSAHPK	HMMQPYKIDVLPCLDGYL	799		
OSTRICH	694	ELLASCLFLLSLPDPDIIMLDIKAYIPALQAFKGLSHTPLADAGLDALEDWSAHPK	HIMQPYKIDVLPCLDGYL	770		
TURTLE	732	ELLASCLFVILSLPHDIIMLDIKAYIPALQAFKGLSHTPLADAGLDALEDWSAYIPK	HIMQPYKIDVLPCLDGYL	808		
ALLIGATOR	692	ELLASCLFVILSLPHDIIMLDIKAYIPALQAFKGLSHTPLADAGLDALEDWSAHPK	NIMQPYKIDVLPCLDGYL	768		
SOFTCORAL	730	DLKSSCLFVILSLPNEVLCDIDIIIPTLTKFVFLKGLGFLPLAEALDALDTSWTAELPS	EILHPYLEREVLQCLDGYL	806		
STONYCORAL	741	DLVSCLEFVILSLPTEIVLTDLVVSSVAALKLTPFKLGLSHTPLAEAGLDALESWTALPA	DKLKPFLREILQCLDGYL	817		
ACORN WORM	741	DLASCLFLVIALPHEI IASDVAAVPALELTPFKLGLSYPLAHAGLDALETWAFRLQH	NALQPYKIDILPCLDGYL	817		
LANCELET	743	DLASCLFVILSLPHDIIMLDIKAYIPALQAFKGLSHTPLADAGLDALEERWLLNLP	SALPHPHHILPYLDGYL	819		
SEA URCHIN	750	DLASCLFLLSLPHQVVENQVHDVPAKLPFKLGLSHTPLAEAGLDALEWIRYIP	DVLKPYQAQVLPCLDGYL	826		
STARFISH	743	DLASCLLVLVSLPHEIVQAEVAHLVPALELTPFKLGLSHTPLAEAGLDALEERWMLHLLP	DSLQPHLKVILPCLDGYL	819		
TERMITE	773	RSQGVASGDV-----IIEKELMVLGRRNRTNYSQNK--VARKKIEHPESLSQLQHEIISFLGQLDSTTCLAL		841		
SHRIMP	791	RSQETGGEAEV-----HTRVITVKMAFARQRKVDQKKMKE-----SKRVEETAMQKIQMLIRLIGSLDPLLR--L		855		
SCORPION	800	LASDNIISLQPLk-----NIHTFTKQSLVVKKLPKLSIQY--KKIKQTDLHESSELIKVQHRIIRLRFGLSVGNQYNFAM		869		
ALVINELLA	768	KSATDTPFSA--aATDQMIILSTTKSNHFKGRRKIPKVLKQ--kRKTLSERNQESQLAEIRRRCVLLGLSGGIVNML		844		
CAPITELLA	814	TSSADEKNDTl-----SLVQKDPMKKQKPKIPVLLKQ--TMFDAEKGESELEIQKRCVLLGLSGGINSNAL		872		
SPONGE	806	KATSVQLKEEe-----DGGRGQYATRYARM--KMVEK--WSEGLHQSRRDITSVRRRIILLLGLSGGVNNE		882		
OYSTER	803	KTMD--QGADD--vSENTM--EMNKS--GKGRKLPVRLKQ--pK--TDSKQVETQLAKVQRVMTYGLRGLGGEVNFAL		873		
SNAIL	799	KTVD--TGAED--vSVETLVTVSSSKS--KYRGGKLPVRLKQ--rKPVDLDKQYESQLSVVKQKIVTYLGLSGGSMNFAL		871		
TRICHOPLAX	790	KSSADDTTET---LVEDSSKALKARTGKAK---KLPVKNVNP-----TGSKDSPLAQVRLRIVQLLGRGLGNTNSLV		856		
SEA ANEMONE	799	KSATDAVEEE---QQQVSRRTATLRSYSLRGLKLSLYIDFvsKRNILPQVGESSLVTVIRVQLIRLLGLGGLGHTNLC		874		
PRIAPULA	820	KTTE--GADS--vpT--PTVAITSANAT--RGRKKIPVLLKQ--sGRK---MAEDSALTARMRIVRFLGGLGANNISL		887		
ESHARK	808	KTAAF---D---EAQNNWEGMNNINPSRKGSKVLFHHTTK---SKEFLVSEDSAITAVRRRIVRLLGLSGGQNNRSL		876		
STERLET	819	KTASN---D---EEQNNWVMSLSRSTKGYGRVLMRLK---AKRFLTEDSPTALVRRRIVRLLGLGGLGQNNRSL		888		
COELACANTH	809	KTSSISA---G---DTPSSWEVRLSRAAQKGDHVKVILRLK---AKAVSLNEDSSLGAVRGRVVRVLLGLSGGQNNRSL		878		
HUMAN	810	KTSSALS---D---ETKNNWVSALSRAAQKGNPKVVLKHLK---TKNLSSENAISLEEIRRVVQMLGSLGGQNNKSL		870		
CAECILIAN	801	KTASSA---D---EYQNSWVMSLSRAAQKGNPKVVLKHLK---TKTSLDQDVSLASIRNRVVQILGSLGGQNNQSL		879		
PLATYBUS	803	KTALS---D---ETKNNWVMSLSRAAQKGNPKVVRHLK---AKATAPVEDLSLESVTRVVRVLLGLSGGQNNRSL		872		
CANARY	800	KSSTST---V---ESQNNWVMSLSRAAQKGNPKVVIQRIR---AKTSLVNSPSLQAVRTRVARLLGLSGGQNNHNL		869		
OSTRICH	771	KNSAST---V---EPQNNWVMSLSRAAQKGNPKVVIQHLRR---AKT--SLVGDPSLEAVRTRVARLLGLSGGQNNHNL		839		
TURTLE	809	KTGSA---D---ESQNNWVMSLSRAAQKGNPKVVIQHLRR---AKTSLDNLSEAVRTRVVRVLLGLSGGQNNRNL		878		
ALLIGATOR	769	KTATSP---D---EFQNNWVMSLSRAAQKGNPKVVIQHLRR---AKALSLNEDLSLEAMSRVVQILGSLGGQNNRSL		838		
SOFTCORAL	807	KTASEL---ET---SNEKETLRSRKSQKTKA---SKS--SKRNPEEN--SPLNKVHRILILLGLGGLGKCNLGL		870		
STONYCORAL	818	TLGLDI---QL---HNECNTIVLITSSHTSRGKRLPLKLLK---KPSQSQMTELTPLAKVRKILRMFGLGGETNILL		889		
ACORN WORM	818	KTVSDTNAEN--asS--QTVSLTMTRTG--KRRNKIPRLKLP--aTQD--GS--DESPITIVLKIIVHLLGLLGGSTNGYL		887		
LANCELET	820	QTAADTGSSS--ssDGFQTVSLTAASS--RGRKKIPVLLKLA--aAER--NQVQESDLVKARLIRVRLGLSGGLGHTNACL		892		
SEA URCHIN	827	GAG--SGSED--egSRPEVLVQTASS--RGRRRIPSKLLK--aKDN--DQSDPSLRSVQLIRLIRLLGLSGGQNNVGL		897		
STARFISH	820	RGTI--TQGS--aadVVQTVTMASASSGRAGKRLPAKLKIG--aSTT--CQTQDPSLRSVQLIRLIRLLGLSGGQNNAYL		893		

Supplementary Figure 3: DNA-PKcs COBALT Metazoa Vertebrate Invertebrate

TERMITE	842	LKDPQQ-EED---VIPWATCLqqPLVFPPLPFKDMKLNINLEKLIIPRVVELAMTSSDRYTRFTACELLHGI VMLILGSGQE	917
SHRIMP	856	HTIPQDpDTIASAAVRWNVQK1--VKFATPFHEHKID IYLDLPHVVDLAVNSSDRQTKVAASELLHSI IILMI GTGAQ	933
SCORPION	870	ISA-DK-IKIHVEVAWVDINKqHLKFLYLPIDVKLEIFLDKFLPRIVLSTASQRTKVAACELLHAVVTFMVGGCAQ	947
ALVINELLA	845	VKSSTE--QVTKSAMAWDNVK--HLKFHVFPVDIKPVIYLDVFLPRVVEIATTSSECQTKAAACELLHSFVLYMLGRSSQ	920
CAPITELLA	873	VFGQTA--NPPDLVAWDSQD--HLKFDLPFLDIKTPIYFDALPKVVTLATVSSDRQTKVAACELLHSLVLLMLGRSSA	947
SPONGE	883	SKVPS----QHSLVSWSDSR--RLGFVFPFDLKEIYLDPLPVTVCCELALSSSDRQTKVAACEFLHAAMLVFIKGTQ	955
OYSTER	874	LSG----SDVCEAIWADEAQ--HLRFDPVFPMDMKPIYDFPFLPRIVELATKSGDRQTKVAACELLHSLILLCVGRSAT	947
SNAIL	872	LAR-RE-EEISRRAIWADTEQ--HLRFDIPFDMKPSIYDFPFLPHVVELATQSSNRQTKVSAACELLHSLILYTLGRSAQ	947
TRICHOPLAX	857	IRKGN-DGS-SQAVAWDNHK--RLPFAIPFQDMKPIIHLDPFLPRVVELATSSDRQTKIAACELLHALVLYMLGRGAQ	932
SEA ANEMONE	875	LGSDDG-VDS-GSAVAVDTPV--HLPFAVFPQDMKPIYLDVFLPRVVELATSSNRQTKVAACELLHSLVLYMLGKGV	950
PRIAPULA	888	ISC-DA-EDIKAVVAWDAEK--NLKFGVFPDMKPIYDFVFLPRVTDLALSSSDRQTKVACELLHALLLYILGTGAQ	963
ESHARK	877	VTAVSA-EEMMKRCIAWVTEK--PLSFVFPFMDMKPIIYLDSPFIPRISELALSASDRQTKVAACELLHSVAYTLGKGSQ	953
STERLET	889	VTATSA-EEMMKKFAVDSEK--RLNFAVFPDMKPIYLDLFLPRITELALSTNDRQTKVAACELLHSVVFMFLGKGSQ	965
COELACANTH	879	VTAAS-EEMMKKFAVSDTEK--RLSFVFPFMDMKPIYLDVFLPRVVELATSSDRQTKVAACELLHSVVVYMLGKGSQ	955
HUMAN	871	LVTSS--DEMMKSVAVDREK--RLSFVFPFDMKPIYLDVFLPRVTEALATASDRQTKVAACELLHSMVMFMLGKATQ	947
CAECILIAN	880	VTASCA-EEMMKKFAVSDTEK--RLSFVFPFMDMKPIIYLDVFLPRVTEALATSSDRQTKVAACELLHSMVVYMLGKASQ	956
PLATYBUS	873	VTAASA-DEMMKCVAVDTEK--RLSFVFPFMDMKPIYLDVFLPRITELALSASDRQTKVAACEVLSI VFMFLGKASQ	949
CANARY	870	VTATSA-EEMMKKCVSDTEK--HLSFVFPFMDMKPIYLDLFLPHVTEALALSASDRQTKVAACEVLSI VTYMLGKASQ	946
OSTRICH	840	VTATSA-EEMMKKCVSDTEK--HLSFVFPFMDMKPIYLDLFLPRVTEALALSASDRQAKVAACEVLSI VAYMLGKASQ	916
TURTLE	879	LTAAS-EEMMKKFAVSDTEK--HLSFVFPFMDMKPIYLDLFLPRVTEALALSASDRQTKVAACEVLSI VMYMLGASQ	955
ALLIGATOR	839	VTAAE-EEMMKKFAVSDSEK--HLNFAVFPDMKPIYLDLFLPRVTEALALSASDRQTKVAACEVLSI VMLGKASQ	915
SOFTCORAL	871	LEGGEG-SVA-SSGIWADTKQ--HLSFVFPFMDMKPIYLDLFLPRVVELATSSDRQTKVAASEVPHSLVFLMLGKSVQ	946
STONYCORAL	890	LNDTG--INS-SNAVVDWTEK--HLTFVFPFMDMKPIYLDLFLPRVVELAASDRQTKVAACEVLSI VHYMLGKSVT	964
ACORN WORM	888	LES-SK-EEIAKKA VAWDTEK--HLQFPVFPMDMKPIYLDLFLPRVVELATSSDRQTKVAACEVLSI VLYMLGKGSQ	963
LANCELET	893	VTGLTA-EDLAKRAVAVDTPQ--HLQFAVFPMDMKPIYLDLFLPRVTEALATSSDRQTKVAACEVLSI VLYMLGKGSQ	969
SEA URCHIN	898	LET-SA-QEELNVAWDSQP--RLNFPVFPDMKPIYLDLFLPRVTEALATSSDRQTKVAACEVLSI VLYMLGKGSQ	973
STARFISH	894	LET-SA-EEIAKVA VAWDTPQ--RLQFAVFPDMKPIYLDLFLPRVTEALATSSDRQTKVAACEVLSI VLYMLGKGSQ	969
TERMITE	918	AQT--SHP-DKYSLEFRKLSLPLLLKGCDDPDAIHRLLNLLVLQVHVYSSKFKLKSKEVEILIQTLMDGITHTPTDIALR	994
SHRIMP	934	KSQETQLK-EPMYLYRHLFSAMLRLACDPDHDVTRQLFLTLSTYQTIHWFTNRRNFENVDIMVLEALMEGIVTANDPALR	1012
SCORPION	948	QQPELQAI-YSMKKLYKNVLPALLQLACDVEVARKLFEPPTFQLIHWFTTKRMINSDETKQFVQVIWDLGVQSKDAVFR	1026
ALVINELLA	921	QPKTKAARgEMDKLYQKLFVPLLQLACDTEQVARGFPLVMQLIHWFTSVMFQSGEGTKILLECIMDGLVDPNTALR	1000
CAPITELLA	948	QPT---G-PMMAAIYRKLFPQMLKLA TDVQVSRQLFPEPLMLQI IHWFTKSNNSHRPDEALLNSLMDGIVSPSDSAVR	1022
SPONGE	956	QSV---QKK-NPMTKLYQKLPVALLQLACDVRVAEQLFRPLVQMIHWFTTRNTQYESPDTVTLLAEALLEGIEHPTNASLR	1032
OYSTER	946	QPA--RER-YSMAPLYKMFPSILQLACDVPDLVTQQLFEPLVQLIHWFTGNKNKAES EESMALLDAIYDGIQPNDTALR	1024
SNAIL	948	QPGEIQRK-NPMDLSYRKLFPALLSLSCDVEQVCRQLFEPLVQKLIHWFTGNKNKAES PESMALLDSIFDGLVQQDNTMLR	1026
TRICHOPLAX	933	QDGGTGSV-TYGNLYKRIIPALLTLASDVEQVSQLFQPLVQYLIHWFTGNSNYESVETIALLNALLDGVIHSTDSALR	1011
SEA ANEMONE	951	QPDGKKA-LPMQNLWKLIIPVLLQLACDVEQVSRQLFPEPLVQKLIHWFTNRRKYESPETIALLDALLEGVHPTDTSLR	1029
PRIAPULA	964	QDSTKSK-RPMSALYSRFLPVLRLQLACDVEQVAVQQLFEPLVQMIHWFTNRRMFESPETMCLLDAIMEGIVDATDAALR	1042
ESHARK	954	ISEGQQ---ETFLYKLNRLFPVLLRLGCDVDTVTRQLFEPLVQKLIHWFTSNRRKYES EESMALLDAIYDGIQPNDTALR	1030
STERLET	966	IPERGEKST-PPMYRKYRIFPVLLRLACDVDQVTRQLYEPLVQKLIHWFTNRRKYESQDVTAMLEAILDGVIVDPVDTSLR	1044
COELACANTH	956	IPERCGGV-PPMYRKYRIFPVLLRLACDVDQVTRQLYEPLVQKLIHWFTNRRKYESQDVTAMLEAILDGVIVDPVDTSLR	1034
HUMAN	948	MPGEGQA-PPMYQLYKRIFPVLLRLACDVDQVTRQLYEPLVQKLIHWFTNRRKYESQDVTAMLEAILDGVIVDPVDTSLR	1026
CAECILIAN	957	MPKQDQL-PPMYQLYKRIFPVLLRLACDVDQVTRQLYEPLVQKLIHWFTNRRKYESQDVTAMLEAILDGVIVDPVDTSLR	1035
PLATYBUS	950	IPGNGQS-PPMYQLYKRIFPVLLRLACDVDQVTRQLYEPLVQKLIHWFTNRRKYESQDVTAMLEAILDGVIVDPVDTSLR	1028
CANARY	947	MPGCGQP-PPMYHLKRVFPVLLRLACDIDQVARQLYEPLVQKLIHWFTNRRKYESQDVTAMLEAILDGVIVDPVDTSLR	1025
OSTRICH	917	MPGCGQP-PPMYQLYKRIFPVLLRLACDVDQVTRQLYEPLVQKLIHWFTNRRKYESQDVTAMLEAILDGVIVDPVDTSLR	995
TURTLE	956	MPDGGQA-PPMYQLYKRIFPVLLRLACDVDQVTRQLYEPLVQKLIHWFTNRRKYESQDVTAMLEAILDGVIVDPVDTSLR	1034
ALLIGATOR	916	MPGGRQS-PPMYQLYKRIFPVLLRLACDVDQVTRQLYEPLVQKLIHWFTNRRKYESQDVTAMLEAILDGVIVDPVDTSLR	994
SOFTCORAL	947	IPDASSQS--PLEKLKRVFPVLLQLACDVEQVSRQLFPEPLVQKLIHWFTNRRKYESPDTIILLETLLDGIHPTDTSALR	1024
STONYCORAL	965	QPQGFKS--PMEHLKRVFPVLLQLACDVEQVSEQLFKPLVQKLIHWFTNRRKYESPDTMALLDAIYDGIHPTDTSALR	1042
ACORN WORM	964	QDSTQAR-APMEKLYKRVLPALLQLSCDVEQVARGQLFPEPLLSQLIHWFTNRRKYESPETIALLDAIYDGIHPTDTSALR	1042
LANCELET	970	QPGEMQK-NPMTRLYKRVFPVLLQLACDVEQVARGQLFPEPLVQKLIHWFTNRRKYESPETIALLDAIYDGIHPTDTSALR	1048
SEA URCHIN	974	QDQREAR-SPMQLYKRVFPVLLQLACDVEQVARGQLFPEPLVQKLIHWFTNRRKYESDETSLLNAILAGVHPTDTSALR	1052
STARFISH	970	QPQRQAK-SPMQLYRVPVLLRLACDVEQVARGQLFPEPLVQKLIHWFTNRRKYESDETTALLNAILAGVHPTDTSALR	1048
TERMITE	995	DFSARCLHEFVWSVKQ-----SHVNIKVMKQIYSFCLHPCSKRLGAALVLSVYTVLREEESVNVQFWLELLYH	1067
SHRIMP	1013	DVSAQCLAEFVWKRQCC--RQNSVSNIKSI IKRIFSFCKHPSAFKRLGALAWNSIYREIREDDQAVD IWTLLLAH	1090
SCORPION	1027	DFSARCLREFVQWSIKQTSVREQEENPIGMNVNLCLNYSLHPNPKYRLLGALAFNSIYTFREEESLVDKFTLEIAVH	1106
ALVINELLA	1001	DFSALCVHEFLQWAIKQTTKKQLESSPNVEMLMNWIYNLARHPSAFKRLGASLAFNSIYTFREEDSLVDIFTFEIMVV	1080
CAPITELLA	1023	DFSACIREFLAWSIKQTSPEKMEAGANPKRLLKRMYSLEBHPSSMRLGALAFNSIYVSVFREDALVDQFSLQILSV	1102
SPONGE	1033	DPSAQCIKEFLVWSIKQTSKQKERSPNTKSLKRLYSALHPSAGHPSAKRLLGALAFNSIYTVLREEESLVDVFIIEILVV	1112
OYSTER	1025	DFCAVCLREFLKWSIKQTT--KNVEKSPINAKSLKRLYSALHPSAFKRLGALAFNSIYTVFREDNAMVNLVTFQILVH	1102
SNAIL	1027	DFAAQCLREFLKWSIKQTSKAMEETNPRNVTSLKRMQSFALHPSAFKRLGALAFNSIYVMVFREEQSLVDRTFQILVL	1106
TRICHOPLAX	1012	DFCAKSLREYLHWSIKQTTKKQEKSTNNAKSLKRLYSALHPSAFKRLGALAFNSIYVVLREEESTLVDTFIFEILVN	1091
SEA ANEMONE	1030	DPSAQCIREFLQWSIKQTSKQLEKSPINIKSLKRLYSALHPSAFKRLGALAFNSIYTVFREDSLVDVFIIEILVT	1109
PRIAPULA	1043	DFCGCIREFLIWSIKQTTVRRQERSPNTKSLKRLYSALHPSAAKRRGATLVFNPIYTVLREEEMLVDTFIIEILVT	1122
ESHARK	1031	DFCGCVREFLKWSIKQTTPEQQAESPANTKSLFKRLYSALHPSAFKRLGALAFNSIYREFREESALVDQFIFEVLVV	1110
STERLET	1045	DFCGCQREFLQWSIKQTTTPKQEKSPANTKSLFKRLYSALHPSAFKRLGALAFNSIYRQFREESTLVDQFIFEILLVI	1124
COELACANTH	1035	DFCGLCIQEFLKWSIKQTTTPKQEKSPANTKSLFKRLYSALHPSAFKRLGALAFNSIYKREFREESALVDKVFVFEALVV	1114
HUMAN	1027	DFCGCIREFLKWSIKQITPQQEKSPVNTKSLFKRLYSALHPSAFKRLGALAFNSIYREFREESLVEQVFVFEALVI	1106
CAECILIAN	1036	DFCGHCIREFLKWSIKQITPQQEKSPVNTKSLFKRLYSALHPSAFKRLGALAFNSIYREFREESLVEQVFVFEALVV	1115
PLATYBUS	1029	DFCGCQVREFLKWSIKQTTPEQQAESPVNTKSLFKRLYSALHPSAFKRLGALAFNSIYREFREESLVDQFIFEALVI	1108
CANARY	1026	DFCGCQIREFLKWSIKQTTTPRQEEESPANTKSLFKRLYSALHPSAFKRLGALAFNSIYREFREESLVEQVFVFEALVV	1105
OSTRICH	996	DFCGCQVREFLKWSIKQTTTPKQEKSPVNTKSLFKRLYSALHPSAFKRLGALAFNSIYREFREESLVEQVFVFEALVV	1075
TURTLE	1035	DFCGCQVREFMKSQIKQTTTPQQEKSPVNTKSLFKRLYSALHPSAFKRLGALAFNSIYREFREESLVEQVFVFEALVV	1114
ALLIGATOR	995	DFCGCQIREFLKWSIKQTTTPQQEKSPVNTKSLFKRLYSALHPSAFKRLGALAFNSIYREFREESLVEQVFVFEALVI	1074
SOFTCORAL	1025	DLSALALEEFLRWSIKQATKQLEKSPINIKSLFKRLYSALHPSAFKRLGALAFNSIYRVFREESLVENFTIEILVT	1104
STONYCORAL	1043	DPSAQCIREFLQWSIKQTSKQEKSPINIKSLKRLYSALHPSAFKRLGALAFNSIYTVFREESLVDIFVLEILVN	1122
ACORN WORM	1043	DPSACVREFLQWSIKQTSKQTEKSPINIKSLKRLYSALHPSAFKRLGALAFNSIYTVVREESLVDQFVLEILVI	1122
LANCELET	1049	DFSSRCVREFLQWSIKQTTTPKQEKSPINIKSLKRLYSALHPSAFKRLGALAFNSIYRDFREESLVDQFVLEILVI	1128
SEA URCHIN	1053	DFCARCISEFLRWSIKQTSKQEKSPINIKSLKRLYSALHPSAFKRLGALAFNSIYTFREEESLVDQFIFEILLVV	1132
STARFISH	1049	DPSACCLREFLKWSIKQTSKQEKSPINIKSLKRLYSALHPSAFKRLGALAFNSIYTVFREESLVDQFVLEILVT	1128

Supplementary Figure 3: DNA-PKcs COBALT Metazoa Vertebrate Invertebrate

TERMITE	1068	MVMNLSLSEETDSILGGQEVVAVNHIERVLKEKASLFN--KEDNIRRKPEFEG---ILLKDAVSWLLKCGTVQVEC	1142
SHRIMP	1091	LMTSLDLAQVDDPALGTHTQTKSAINHIERIIRVKSDLFQ--KKSQRRLPPGFGDGT---LVDVLKWLFPQCGRPKALV	1165
SCORPION	1107	FIESLAIHAYDDKILGTQDKCKQALNHLIERIMEVKAALLS--KTSKRRRLPRNINDS---ILPEVVEWILKNCGLQTEC	1181
ALVINELLA	1081	FVESLAIHAGDDKSLGTQKQAKQALSHLDRIIKKADLLS--CASKRRKPKYKWEAT---LQICLWLVRQCGRPQTEC	1155
CAPITELLA	1103	LVNSLALAHRRDCKSLGTQEQCKSALLHVERILIKKQVTFN--KDSQRIRKPRGRDAN---MTTAVRWLLRQCGRPQTEC	1177
SPONGE	1113	MVNSLKLAKHQDAQSIGTVQCCSLSDHMSRIIKAKSSTCLsKANKNRVPRGLKASAD---LSILTAWLLAQCGSIETEA	1188
OYSTER	1103	FVESLAIHAEDESSMGTTQCKMVLDMHMERIKKKNVLS--KEDKNRTEPKQVSW---VKLDIAVRWLMRQCGRPQTEC	1177
SNAIL	1107	FVESLGIHAGDEASLGTQEQCKKALEHVEKIVCKRVDILR--KPSPHRKEPSEWSK---QTLDIIVRWLVRQCGRPQTEC	1181
TRICHOPLAX	1092	YVNSLALSHTDEKSLGTQEQLSKALAHIERIKKASTLN--KESKNRRTPTGFMT--K-TVTLHHVWNWLVQCGRPQTEC	1168
SEA ANEMONE	1110	YLESLALAHHTDDPAQGTQEQCSQVISHLERIKTKATLLD--KENQRRIIPRGFQMLD-SITLSSHLLPLLIKLQCGRPQTEC	1187
PRIAPULA	1123	FVDSLALAHNDKESLGTQEQCAQALDHIERILRGAHLLN--KDKKSRRRPKEFTD---ATLFTTVGWLLQCGRPQTEC	1197
ESHARK	1111	YVESLALAHADNDSLGTQVQCCDAIDHLNRIIKQKASALN--KPIKGRVPRGFPPDQ--PVSLKEVVMWLLTQCGRPQTEC	1187
STERLET	1125	FVESLALAHHTDEKSLGTQEQCCDAIDHLKRIIKKASALN--KAKKRRRPRGFPDQ--PVCLLDVIMWLLVQCGRPQTEC	1203
COELACANTH	1115	YVESLALAHHTDEKSLGTQEQCCDAIDHLKRIIKKASALN--KAAKTRVPRGFSPDK--VFCVLDVIMWLLVQCGRPQTEC	1191
HUMAN	1107	YVESLALAHADKESLGTQEQCCDAIDHLKRIIEKKSALN--KAKKRRRPRGFPDQ--SLCLLDLVKWLHACGRPQTEC	1183
CAECILIAN	1116	YLESLALSHQDEKSLGTQEQCCDAIDHLKRIIHKKAPSLN--KTLKRRRPRGFPSTKsSFCVLDVIMWLLVQCGRPQTEC	1193
PLATYBUS	1109	FVESLALAHHTDEKSLGTQEQCCDAIDHLKRIIEKKSALN--EENKRRRPRGFPNAR--SVRLLDVIMWLLVQCGRPQTEC	1185
CANARY	1106	FVESLALAHHTDEKSLGTQEQCCDAIDHLKRIIHKKAPSLN--KEGKRRVPRGFPPTK--SVCLLDVIMWLLVQCGRPQTEC	1182
OSTRICH	1076	FVESLALAHHTDEKSLGTQEQCCDAIDHLKRIIEKKSALN--RAGERRVPRGFPAK--TVCLLDVIMWLLVQCGRPQTEC	1152
TURTLE	1115	YLESLALAHHTDEKSLGTQEQCCDAIDHLKRIIHKKAPSLN--KAEKRRRPRGFPNAR--SVCLLDVIMWLLVQCGRPQTEC	1191
ALLIGATOR	1075	FVESLALHTHTDEKSLGTQEQCCDAIDHLKRIIHKKAPSLN--KAEKRRRPRGFPQAE--SLCLLDVIMWLLVQCGRPQTEC	1151
SOFTCORAL	1105	YLESLEMAHEDEISLGTQEQCEVISHLERIIVSKAPSVLL--NVNKKRRVPRGFSA--D-TTTLRHLIPWLVKCGCQTEC	1181
STONYCORAL	1123	YLECCLSHGDEEARGTQEQCVIHLIERIHSRAQLLV--KENHRRRIPRGFASQ--SITLIHMIPLWLVKCGRPSSEC	1200
ACORN WORM	1123	YNSLALAHHTDEKSLGTQEQCVRVVDHLIERIKKAPSLN--RTSKTRRVRPRFNRRD--CPTLSHVTVWLLVQCGRPQTEC	1200
LANCELET	1129	FVESLALAHHTDEKSLGTQEQCVAVLTHLDIRITKADLLN--KHSKRRRPRGFDRES--PPTLPDLVTVWLLVQCGRPQTEC	1206
SEA URCHIN	1133	FVESLALAHHTDEKSLGTQEQCVSEVLKHLIERIMRVKAPSLN--KESKNRVRPRGLPDC--SPTLSHMVWLLVQCGRPQTEC	1210
STARFISH	1129	FVNSLALAHHTDEKSLGTQELHGVVNLHLIERIKKADMLN--KESKIRRIIPREFPAGV--CPTLSMLVIMWLLVQCGRAQTEC	1206
TERMITE	1143	RHKCMELVYVLA---PLLVPCKSGSEFVSWAATHSw---TSIIRICEGSKES----GGIT-VTPTLKHRLNEVALVYVV	1211
SHRIMP	1166	RHTCMELLASLA---PQVKGCAVSRDFIEKYVWYVTSKIL--SEIVDILEGGGEA--KMGISYVK---NPTASSKHIGSSLDKIN	1237
SCORPION	1182	RHKCMELVYVLA---PCLSGFNGCKDYFSLHLETKGK--KFFLNCFESEMSN-----TVPSFNQNDGLKPII	1243
ALVINELLA	1156	RHACMELVYVLSstS---LPGVKRPHDFPSALIKGDKK---YLLQRFESGMYCLKEEQHGIS--KRPKVTDMDCRFALKSAL	1228
CAPITELLA	1178	RHVCMLRVYVLA---PCVHEINGARELFSVLLSQGNS--EYFIQRFEFGMYS--SARMGLN--QKPTMSRVQENFSLNAVL	1249
SPONGE	1189	RKMCRLVYVLA---PPSSNVNIRMWIRKTYIESEGG---NYFVTRFESHGHS-----GIL--KAPTLPAP---NINIAI	1253
OYSTER	1178	RHACMLVYVLA---PCITGIKSTKDYFQFTYKESG---ASYFINRFEFGKQO---KYGLL--SCPEMTAVDSSFSVQNAV	1246
SNAIL	1182	RHACMLVYVLA---PLIPGISPPDYFKAALDIQN--ASYFVVRFEFGGQV--GDRGGLC--GHPTPSKVAENFSLKAVL	1253
TRICHOPLAX	1169	RHQCMLVYVLA---PQLSGVSTIQDWKTIIGSSS---VTFITRFEFGGGS---KY--GIG--RYQTALDISDTPNLRSMK	1237
SEA ANEMONE	1188	RHQCMLVYVLA---PLLHGIGSAIWMKNTHK--EH--DSFFVRRFEFGGGR--GN---GIL--TYP--TLADMGAFFSLKETL	1256
PRIAPULA	1198	RHKCMELVYVLA---PQVKGCAVSRDFIEKYVWYVTSKIL--SEIVDILEGGGEA--KMGISYVK---NPTASSKHIGSSLDKIN	1237
ESHARK	1188	RHKCMELVYVLA---PQVKGCAVSRDFIEKYVWYVTSKIL--SEIVDILEGGGEA--KMGISYVK---NPTASSKHIGSSLDKIN	1237
STERLET	1204	RHKCMELVYVLA---PQVKGCAVSRDFIEKYVWYVTSKIL--SEIVDILEGGGEA--KMGISYVK---NPTASSKHIGSSLDKIN	1237
COELACANTH	1192	RHKCMELVYVLA---PQVKGCAVSRDFIEKYVWYVTSKIL--SEIVDILEGGGEA--KMGISYVK---NPTASSKHIGSSLDKIN	1237
HUMAN	1184	RHKCMELVYVLA---PQVKGCAVSRDFIEKYVWYVTSKIL--SEIVDILEGGGEA--KMGISYVK---NPTASSKHIGSSLDKIN	1237
CAECILIAN	1194	RHKCMELVYVLA---PQVKGCAVSRDFIEKYVWYVTSKIL--SEIVDILEGGGEA--KMGISYVK---NPTASSKHIGSSLDKIN	1237
PLATYBUS	1186	RHKCMELVYVLA---PQVKGCAVSRDFIEKYVWYVTSKIL--SEIVDILEGGGEA--KMGISYVK---NPTASSKHIGSSLDKIN	1237
CANARY	1183	RHKCMELVYVLA---PQVKGCAVSRDFIEKYVWYVTSKIL--SEIVDILEGGGEA--KMGISYVK---NPTASSKHIGSSLDKIN	1237
OSTRICH	1153	RHKCMELVYVLA---PQVKGCAVSRDFIEKYVWYVTSKIL--SEIVDILEGGGEA--KMGISYVK---NPTASSKHIGSSLDKIN	1237
TURTLE	1192	RHKCMELVYVLA---PQVKGCAVSRDFIEKYVWYVTSKIL--SEIVDILEGGGEA--KMGISYVK---NPTASSKHIGSSLDKIN	1237
ALLIGATOR	1152	RHKCMELVYVLA---PQVKGCAVSRDFIEKYVWYVTSKIL--SEIVDILEGGGEA--KMGISYVK---NPTASSKHIGSSLDKIN	1237
SOFTCORAL	1182	RHKCMELVYVLA---PQVKGCAVSRDFIEKYVWYVTSKIL--SEIVDILEGGGEA--KMGISYVK---NPTASSKHIGSSLDKIN	1237
STONYCORAL	1201	RHKCMELVYVLA---PQVKGCAVSRDFIEKYVWYVTSKIL--SEIVDILEGGGEA--KMGISYVK---NPTASSKHIGSSLDKIN	1237
ACORN WORM	1201	RHKCMELVYVLA---PQVKGCAVSRDFIEKYVWYVTSKIL--SEIVDILEGGGEA--KMGISYVK---NPTASSKHIGSSLDKIN	1237
LANCELET	1207	RHKCMELVYVLA---PQVKGCAVSRDFIEKYVWYVTSKIL--SEIVDILEGGGEA--KMGISYVK---NPTASSKHIGSSLDKIN	1237
SEA URCHIN	1211	RHKCMELVYVLA---PQVKGCAVSRDFIEKYVWYVTSKIL--SEIVDILEGGGEA--KMGISYVK---NPTASSKHIGSSLDKIN	1237
STARFISH	1207	RHKCMELVYVLA---PQVKGCAVSRDFIEKYVWYVTSKIL--SEIVDILEGGGEA--KMGISYVK---NPTASSKHIGSSLDKIN	1237
TERMITE	1212	RWLRMVLTSFDCYVWLFGEELVKPSVLWGTEGLDNTSETRIFEAAVYFIQHVCHRDASSVTCLLST---dtKDVLEITP	1287
SHRIMP	1238	IFLEALSASLDGYCWLIGQIVPAKLLNHSSEL---QLFSATYFINEMALLTVSEYMKNHDAf-----QNAVATP	1305
SCORPION	1244	NWLEGLHTMLDCYVWVFGQSVLKLSDIFNDASN--RES--KFFPSIEFFLKTLCI--DFDQVQAFPT---hesVKKQIFSP	1316
ALVINELLA	1229	TWFDYLLCTLDYTWIFQGLNINPSRILVVPDE--KGT--VLFVLSYFFDKLAQGDIEKAAVLFQDk-----PQQIFTP	1299
CAPITELLA	1250	TWFDVLAALDCYTWVFGRLMSPNQILIASNN--KGT--IIFQVLLHFMELAQEDIISAAVLFPKv-----aDGSSIFTP	1322
SPONGE	1254	NWLQSLQAADVNRWLLKEQYVSPREIFSSSTSS---S-NLFKSIDHFLKCIALVIGEVNPSPEV-----AMATSI	1320
OYSTER	1247	SWFDHYLAALDCYIWFVGSLLNPDIF--SGEG--RQGS--KLLQAMQHFLSVQVMDMDEVGKMFRR---epL--TDVYTP	1318
SNAIL	1254	SWFDMLAVLDCYCWVFGGLSPAKMF--ESSG--FKGT--RVFSLQYVFTEMALGLDLSVAAKQFQR---kaE--AVFPTP	1325
TRICHOPLAX	1238	NWYDYFLAALDCYVWVFGKMMSPQIIGD--KaQLGSC--KIFGSIEFPLSKLCHSLDTEVKLLYS---kSTLQFTP	1310
SEA ANEMONE	1257	LWFDHYLAALDCYTWVFGQLLPADLLRS---KYSS--VLFVLSYFSLNLAALGIQAIAKCPK---tHITDVTAP	1327
PRIAPULA	1270	SWFDHMLAALDCYTWVFSKLLQPTALFAGGTG--KREEt--TCFAMVSDFMPSGEERRRRRWADR---h---VHP	1338
ESHARK	1261	QWMDMLAALDCYNTFVRLAMVKSPELLT---SQET--GFMKAMNFFLKTARHDIATAEBCFTL--G---VKGVLFSF	1330
STERLET	1277	QWMDMLAALDCYNTFVRLAMVKSPELLT---SQET--GFMKAMNFFLKTARHDIATAEBCFTL--G---VKGVLFSF	1330
COELACANTH	1265	QWMDMLAALDCYNTFVRLAMVKSPELLT---SQET--GFMKAMNFFLKTARHDIATAEBCFTL--G---VKGVLFSF	1330
HUMAN	1255	CWLDLALLAALDCYNTFVRLAMVKSPELLT---SQET--GFMKAMNFFLKTARHDIATAEBCFTL--G---VKGVLFSF	1330
CAECILIAN	1267	QWMDMLAALDCYNTFVRLAMVKSPELLT---SQET--GFMKAMNFFLKTARHDIATAEBCFTL--G---VKGVLFSF	1330
PLATYBUS	1259	QWMDMLAALDCYNTFVRLAMVKSPELLT---SQET--GFMKAMNFFLKTARHDIATAEBCFTL--G---VKGVLFSF	1330
CANARY	1256	QWMDMLAALDCYNTFVRLAMVKSPELLT---SQET--GFMKAMNFFLKTARHDIATAEBCFTL--G---VKGVLFSF	1330
OSTRICH	1226	QWMDMLAALDCYNTFVRLAMVKSPELLT---SQET--GFMKAMNFFLKTARHDIATAEBCFTL--G---VKGVLFSF	1330
TURTLE	1265	QWMDMLAALDCYNTFVRLAMVKSPELLT---SQET--GFMKAMNFFLKTARHDIATAEBCFTL--G---VKGVLFSF	1330
ALLIGATOR	1225	QWMDMLAALDCYNTFVRLAMVKSPELLT---SQET--GFMKAMNFFLKTARHDIATAEBCFTL--G---VKGVLFSF	1330
SOFTCORAL	1252	HWFDLVLAALDCYIWFVGSLLNPDIF--SGEG--RQGS--KLLQAMQHFLSVQVMDMDEVGKMFRR---epL--TDVYTP	1318
STONYCORAL	1271	LWFEFVLAALDCYIWFVGSLLNPDIF--SGEG--RQGS--KLLQAMQHFLSVQVMDMDEVGKMFRR---epL--TDVYTP	1318
ACORN WORM	1276	NWFDLVAALDCYIWFVGSLLNPDIF--SGEG--RQGS--KLLQAMQHFLSVQVMDMDEVGKMFRR---epL--TDVYTP	1318
LANCELET	1280	SWFDLVAALDCYIWFVGSLLNPDIF--SGEG--RQGS--KLLQAMQHFLSVQVMDMDEVGKMFRR---epL--TDVYTP	1318
SEA URCHIN	1280	TWLEVLVAALDCYIWFVGSLLNPDIF--SGEG--RQGS--KLLQAMQHFLSVQVMDMDEVGKMFRR---epL--TDVYTP	1318
STARFISH	1280	SWFDLVAALDCYIWFVGSLLNPDIF--SGEG--RQGS--KLLQAMQHFLSVQVMDMDEVGKMFRR---epL--TDVYTP	1318

Supplementary Figure 3: DNA-PKcs COBALT Metazoa Vertebrate Invertebrate

TERMITE	1508	SSV-----LHGDFYFVTFRSAILEHMLACFEHVSCLIKDISANNVQwVISVTEILQYAKIRKSKHQDSTT [3] FER	1581
SHRIMP	1523	TSQGEV---EKGSVHVLISILGPKLIPQFLESPPDALSRCVEMIREGRFLDAMGFASALLTCLIRNADIRKYSVK	1596
SCORPION	1536	TKTRR-----GLIMFSTYQOEISLFPAGINSKHFISLMMNINKSKTT-VLKLIVGLDLSIGVKVEFRYRYGKD	1605
ALVINELLA	1488	SSS-----DHGAMFYACFKSTVNQHLVANCAEFLDHLKWAHDETTT-VGCILISMLEYIRQDRQLRKNLGS	1557
CAPITELLA	1541	VST-SvqCSPHGTLYFAAFKSVVNLNFVKSVEKFPVLLMKRHEANGET-LSSVLIGIAESVISDRPLRKSCHKM	1615
SPONGE	1555	AAQ-----DGLLYITYSGLINNKLLHAKMAIDVLLKNAKTHPQQ--VSVILMLLLEYVQKDFKINNNNNK [5] LCT	1628
OYSTER	1540	YSQ-S-----GELMFLFAFKTTSVHLAKAMAQAVPVLCEHAQKCYR-VMSILVMVDTVSKDKNLRKQISAN	1609
SNAIL	1548	IEY-M-----LGDHFFFLFKTPISSHVA-ASSDVSLLMKNKATVDPHR-VCNVLMAMLENVAQDRIRKSNGR	1616
TRICHOPLAX	1534	ATA-----TLGMFLYTFNSNINAFKAVSNRCLPMLDLAASKSFM-ISGILSGLLDFILRDRGLRQSKGIH	1603
SEA ANEMONE	1542	FSD---GSSVGAVFYTFQASINTYLKNAQSHIPQLVSMATSYSSH-VCSILNSILDQFNDRKTRKRYGSV	1613
PRIAPULA	1554	VSA---kQTTKGSMPFYSTFGHEINHLVGMATVLPKVLDRINRESV-VMTILTDLLDQVQKDRTRKRYGSG	1626
ESHARK	1552	ATQKNfITFSHGGEYFSLFSETINAEELLKSLKSAVTLMRSAENPKM-VSTVLNGMLDQSPFRDHTVRKTQGV	1627
STERLET	1568	TSQKNfITFSHGGEYFSLFQETINSELLKNLDTTVAOLMKSAAENPKM-VSMVLNGMLDQSPFRERVRKTQGSQ	1643
COELACANTH	1556	TSGRNLfITFSHGGEYFSLFMETINSELLRNLNLTAVLMLKSSAAENPKM-VGAILNGLDQSPFRNRTRKQGSQ	1631
HUMAN	1545	SSQGSVfHFSHGGEYFSLFSETINTELLKNLDAVLELMQSSVDNTKM-VSAVLNGLMDQSPFRERANRKHQGLK	1620
CAECILIAN	1558	TSQRNifSFSHGGEYFSLFSETINTELLKNLNTAIVLQMKSSVDNPRM-VGILNGLMDQCFRDRTRKQGVK	1633
PLATYPUS	1549	TSQRNifSFSHGGEYFSLFSATINTELLKNIDTAIVLQMKSSVDNAKM-VGILNGLMDQCFRDRTRKQGEK	1624
CANARY	1547	ASQNLfMNFSGQYFSLFSETINQQLKNLQVIVLRLMKSSISNPQM-VGILNGLMDQSPFRDRVRKQGAQK	1622
OSTRICH	1517	ASRKNfLVNFSHGGEYFSLFSETINEQLKNLQVIVLQMLMSSVSNPQM-VGILNGLMDQCFRDRTRKQGVK	1622
TURTLE	1556	TSQRNifSFSHGGEYFSLFSETINQELKDLDAVILQMKSSVDSPKM-VGILNGLMDQCFRDRVRKQGIK	1631
ALLIGATOR	1514	AAPRNfLFSHGGEYFSLFSETINHELLKNLDAVILQMKSSVDNPRM-VGILNGLMDQCFRDRTRKQGMK	1624
SOFTCORAL	1554	SST-----VGMVFYQTFHNTIEHLLIKNSSEHLPILEYNRDEAQW-VSSTVIALDLSMVKDKELRKMGRK	1622
STONYCORAL	1568	SNDNP---GSSCCCTFYRIFQTSINGFFIERANIHMANLMAKASSPFL-VLSLNGLDQVIRDKILTRNGSS	1641
ACORN WORM	1576	SSA-----GYCGLSFFSHKVPINTQLAQHGQVIVLRLMSSVSNPQM-VGILNGLMDQCFRDRVRKQGMK	1622
LANCELET	1576	KSS----TFQGMVFFSTFKSCICQQLIKTCAESVPLLQQLTAEVPV-VGILHGLLDHLAKDKTRKKEGMA	1646
SEA URCHIN	1572	TSKLSasQTLGLVFLTTYKQIMDQLVKHGQVIMDQVLRNVRDRGT-IGMIYGLEHVAVGNREIRKRYGMA	1647
STARFISH	1585	TSK-----GAVFYTFKTKLNGEMVAQKQVIVPLLVREGGKDVTV-VSSVLNGLLDVLTSSRVRRTHTGMS	1652
TERMITE	1582	SIVNHNKLSFFV---EGNSEQVYQLGLVNLARIMPQ--PDRG-LARCEALQKWVITQLTSRDLQLHYKSRALDVLVC	1655
SHRIMP	1597	SFLKHWPTLAAQA---GKTSLHQSDVLSLLSFLDIREGTIKSHcTSSRSDMVYFNGLLADAKVELQAKIKVLKLLPF	1673
SCORPION	1606	SIMCQWSRLQQL---EESCDIDLQNDITLITKMLDIDSSFIKGNV-NYDSNSIFPSFITLQKSEMSLEFKICVLDLLPF	1683
ALVINELLA	1558	ALLDRVFRILHAWHGASATKETQSMALNLLTKMLIDSKAVCNVQ-QKGFSHMFDMLNMLVDKRLSLSFKSNVLDLAF	1636
CAPITELLA	1616	AITYQWSSLSVWWSFESTASLDTKMVAITLLTKLQIDSTVIIDVK-NKSFYFVKMFLGLISDKNNTLQFKTRVLDLIF	1694
SPONGE	1629	ELLSHWQDLSLW---EDGSKDLKSAAVTLQKIALKPKLLKSA-DVS-KPLVDMYFAMIGDEKLELNFKAVMIDLLPS	1704
OYSTER	1610	SVVEKWRISSTWC---LA-TPELHSMAMLLTLKVLQIDSKVVTSS-SGHFPEVFTYLSLMTKKTLSVKCKILELPP	1685
SNAIL	1617	MVASKWHLESW---QAGSSDLQGLAVLLTLKLLVDSKAVLNVE-KSHFTTVPFSTYCTILAEKKTNLAFKNRALDVLFP	1693
TRICHOPLAX	1604	KILSSWNSLKCW---LTPDAQDQLQISVNLNKLTLDPQFATQSN-DSSFETVFNFLSLLSGTSTLAFKKYVLDLHF	1681
SEA ANEMONE	1614	SIVNSWEVFLDSW---AKDSPLETKMAVLLAKLQIDSSVSNPNTS-HGSPFVFTTYISLADTKLHLKQAVTLFPY	1698
PRIAPULA	1627	TVLQCWGHRLDLW---VASTPDRKDMMLLRLKLLIDSSVATKGS-HSAHRDVTYCYCLLVDAQSTLAFKTRVMELLP	1704
ESHARK	1628	SIVQKWRISSTWC---SENSAESKMAVTLKVLQIDSSVSNPNTS-HEAFMVFHTYTYTLLTDLALNLKQAMILFP	1705
STERLET	1644	GVLGSWTSLQSW---ASSSAESKMAALTLKVLQIDSSVSNPNTS-HLAFVAVFTYTYTLLTDLALNLKQAMILFP	1721
COELACANTH	1632	TVLQNTKLSW---IRSSSPESKMAALTLKVLQIDSSVSNPNTS-HAFAVAVFTYTYTLLTDLALNLKQAMILFP	1709
HUMAN	1621	TVLQNTKLSW---AKDSPLETKMAVLLAKLQIDSSVSNPNTS-HGSPFVFTTYISLADTKLHLKQAVTLFPY	1698
CAECILIAN	1634	AVLQNTKLSW---DKNSAPESKMAVTLKVLQIDSSVSNPNTS-HEAFSAVFTYTYTLLTDLALNLKQAMILFP	1711
PLATYPUS	1625	AVLQNTKLSW---AEDSTPEKIAVTLKVLQIDSSVSNPNTS-HEAFSAVFTYTYTLLTDLALNLKQAMILFP	1702
CANARY	1623	AVLRNWEKLDGW---AKGSSAESKMAALTLKVLQIDSSVSNPNTS-HEAFSAVFTYTYTLLTDLALNLKQAMILFP	1700
OSTRICH	1593	AVLRNWEKLDGW---AKGSSAESKMAVTLKVLQIDSSVSNPNTS-HEAFSAVFTYTYTLLTDLALNLKQAMILFP	1670
TURTLE	1632	AVLRNWEKLDGW---AKGSSAESKMAVTLKVLQIDSSVSNPNTS-HEAFSAVFTYTYTLLTDLALNLKQAMILFP	1709
ALLIGATOR	1590	AVLRNWEKLDGW---AKGSSAESKMAVTLKVLQIDSSVSNPNTS-HEAFSAVFTYTYTLLTDLALNLKQAMILFP	1667
SOFTCORAL	1623	VLLSEWRISLHW---E-NGGELKRSTAILRINILVDPKCLSEVK---SSRGMFKTYNGLLTKTITLVKIQCLELPC	1697
STONYCORAL	1642	VLLNNWTSFEIFW---RTHSAMDLRHSILMILKMLLDPKAVTDCN-RLTFPSLFEMYLKLDKSTTLAFKGVLELPPY	1719
ACORN WORM	1647	AILSNWSSLKSW---SEGATHDQRSSSTLILKLLKQIDSKFASDPT-HAFAKPVDMYLMVMTDSNTSLAFKSRVLEILFY	1724
LANCELET	1647	SLLQSWPKLAPW---EAGALQDSKSTALTLRKLILIDSQVSRDPA-HPAFQPVFTMYLDMTLTSTLTPFKSQVLDLFP	1724
SEA URCHIN	1648	AVLTQWDTLSNLG-QE-----DDFMLNLMKVLQIDSKFATDPT-HPFTRPVFNQVLSMLRDSKSLAWKTQVLDVLYF	1719
STARFISH	1653	AILTQWDTLSNLG-QE-----DDFMLNLMKVLQIDSKFATDPT-HPFTRPVFNQVLSMLRDSKSLAWKTQVLDVLYF	1730
TERMITE	1656	LAGPq---EDTNQELRSALQTLREQHFPQLSTELHSGSVGVNFRKILRGLSESGSCVILLSVVAASAES-QHVLE	1732
SHRIMP	1674	FFTMg---EDIAKSVSEALEMLSLHNFPLHSTEFSEGGARDREYHQAICEILTLELSELSPIQLQVFNLFQRED-KHRYE	1750
SCORPION	1684	FLCDA---FLCKVQALNLDLFTNHFFLYSSELKPGSSQNDYHLAFTKLLIALELTGNEMLLKFKVQIMCRES-THLLE	1758
ALVINELLA	1637	FCSL---PEDYIWLQKELERFVDNPNPQKSDQYRKGSPKYNEYIISFNKILSALELSGNLMLLELLISICKEE-AHAE	1713
CAPITELLA	1695	FCNL---PAEENKQLESLNQFVADCFPMSSLEFHAAGSQQKCYITADRLLELAMELSSGSLMLNLIISVICKEV-KHTE	1771
SPONGE	1705	FLLSs---SPEHQSQLKGLNRLVSLQPLTSELPAAGPLLENYTNIIEKLCNSLVASGSLVLELIIINIMCREV-RHVCE	1782
OYSTER	1686	FATL---PEPHLKLKRLDLRLVADHFPKISTDLPESSPHFKDYIAADRLLTSELSSGSEMELLEISIFCREP-KHVYE	1762
SNAIL	1694	FAAV---PDA---KLKDLVLDGLVADNFPKRSSELTKGTPRFVVDYISAIDKLLSALELSLVLLELISIFCREG-RHVHE	1768
TRICHOPLAX	1682	FLVSs---DKRIRELREHLDRIIVDKFPLKSAEFVVGSPDYNDYVACIDKLLANLKSGLNMLLELIVSMCREK-KHAYE	1758
SEA ANEMONE	1692	FKNL---PDNYQSQLKSCIDTLVTDNPLKSTEFIPGSPRYNDYIATLDKLLVMVTSGLVLVQIVAVLCREE-RHVHE	1768
PRIAPULA	1705	YCEL---PEQETTCLRNLDRMVADFPPLRSSDFIVGSPKYHDYVAAMSQLLDMVEVSGTMLLRVIVCREG-KHAMH	1781
ESHARK	1706	FAHL---PEENLAVLRHALDQFVAHFPMKSEDFPKGTLKYNVDAIKKLLDALELSQSPMLLKMIAILCRDS-RHVME	1782
STERLET	1722	FTNL---LGSSTLADLHNALEVLVAFHFMQSEDFPKGTLKYNVYDYSIKKFLDALELSQSPMLLQMTGILCRDN-KHVME	1798
COELACANTH	1710	FTNL---PEDHLADLKNALDQLVAFNPMKSEDFPKGTLKYNVYDYSIKKFLDALELSQSPMLLQMTGILCRDS-KHCLE	1786
HUMAN	1699	FTSL---TGGSLLELRRVLEQLIVAFHFMQSEDFPKGTLKYNVYDYSIKKFLDALELSQSPMLLQMTGILCRDQ-QHVME	1775
CAECILIAN	1712	FTNL---TGDLSNLDLKNALDQLVAFNPMKSEDFPKGTLKYNVYDYSIKKFLDALELSQSPMLLQMTGILCRDQ-KHFME	1788
PLATYPUS	1703	FTNL---TGDRLNDLKNALDQLVAFNPMKSEDFPKGTLKYNVYDYSIKKFLDALELSQSPMLLQMTGILCRDQ-RHFME	1779
CANARY	1701	FTNL---TGEKLLNDLKNALDQLVAFNPMKSEDFPKGTLKYNVYDYSIKKFLDALELSQSPMLLQMTGILCRDN-RHFME	1777
OSTRICH	1671	FTNL---TGEKLLNDLKNALDQLVAFNPMKSEDFPKGTLKYNVYDYSIKKFLDALELSQSPMLLQMTGILCRDN-RHFME	1747
TURTLE	1710	FTNL---TGDRISELKNALDQLVAFNPMKSEDFPKGTLKYNVYDYSIKKFLDALELSQSPMLLQMTGILCRDN-RHFME	1786
ALLIGATOR	1668	FTNL---TGERLKLKDALDQLVAFNPMKSEDFPKGTLKYNVYDYSIKKFLDALELSQSPMLLQMTGILCRDN-RHCEM	1744
SOFTCORAL	1698	FTSAtIPSEYTLALRSALKTLIADNFPKSSKFEFNNPNKSYDYIAALDKILSALVIGSGLMLLLELISIVCREE-SHSHE	1776
STONYCORAL	1720	FTKS---TEBYLRRLKGLNAFVFNNTNPKSTEFNFGPYNDYVQIDRKLAAFNNSRSLLEVLIAIFCRER-QHVHE	1796
ACORN WORM	1725	FTRI---PEQELSLQGRNLRIADNFPKSSKFEFNNPNKSYDYIAALDKILSALVIGSGLMLLLELISIVCREE-KHVCE	1801
LANCELET	1725	FTVL---PQTLAELKARLDRMVADNFPKSAEFPAGSSKYNDYVAVTKLLSALELSLMLLELISIVMCREA-KHVME	1801
SEA URCHIN	1720	FANV---PEREEKELKSDLDLVANFPKSTDLFAGSPRYNDYIMALNKLITLSVMSSGSLMLLELISIVCREE-KHSYE	1796
STARFISH	1731	FTSL---PDGEQTKLRSALDRLVADNFPKSSKFEFNNPNKSYDYIAALDKILSALVIGSGLMLLLELISIVMCREE-KHAYE	1807

Supplementary Figure 3: DNA-PKcs COBALT Metazoa Vertebrate Invertebrate

TERMITE	1733	DQIQKSLQIFIKRRL--EDKQVKAIEAVFKV-FV-DDQ-YDPSVRLGCAQRFVVRPLLQGCRRSAAREFYRHCIQDLQGLM	1807
SHRIMP	1751	EVMHESLEKFMKRL--PLLKQETLKHIDYDM-YN-DPTCKQNLRYNIMDLVPLPLQQAEAVPTQNFLLTVISAVMAGM	1826
SCORPION	1759	ENIQKCLKLLKCRRT--DSNKERLIAEVPLKM-FL-EDELYPSDMRTHIEKVFVRVILGMISKITLKYFFIDHIKEIMQIV	1834
ALVINELLA	1714	EHIQKFLTKMAKRL--PVDKQPAIEVPIYRI-FC-NESTFKNAHRRRAALERVCVTLRLRAVSVPALKEFFYDHKIDIMFSI	1789
CAPITELLA	1772	NAIQSAFQRFIKRRL--PKDKHKLALDVPYKI-FS-QEGRFTNNQRRAAACEKVSLSMLRHLVSSALTEFYCEHIKEIMKII	1847
SPONGE	1783	EKIQTSLHQFISKL--SEGDVALKFVYEM-FK-NDKDFVAAVKGIGERLCVPLFTECSSAVLLEFFVVKISDVMCIM	1857
OYSTER	1763	TKILESINRFRTRV--PAAKQKSMVDVAYNI-FC-QEDLYPGEVRRTTIEKVALPIRLRHVKSALLEFFTDHMGDLRTTV	1838
SNAIL	1769	DAIQQSLNFTTARL--PAEKQKDALDVPYKIFC-ESG-FQDMIRRTTLERVCPLPIRLCVHKAALTEFFLDHLLDMRIV	1844
TRICHOPLAX	1759	EIQKSLLLFISLSpk--DALGALDVPFKM-FV-DDKSYRPIRRAAIERVCLPMLQKASLKITKDFYVSHIKEIMDII	1834
SEA ANEMONE	1769	EIQKSLAAFIQRLapSSSLVKGAVDVTYRI-FT-NERDHTSNVRLAVLDRVSVTLTLCNASKAGVSEFFSSHVKEIMEII	1846
PRIAPULA	1782	DQLQTSLSRFIHRLL--SADKQKLAADSGYSI-LA-EEGNFPEIRRSCLDNVVLRLRQCCHHAVVEFFRCHLVEIIGII	1857
ESHARK	1783	EGFQVCFQRLAKTG--SCEKQVALLAVYGM-FE-NEGGLSNIRARQSVMDRSLTLITHCSLDALKEPISKIKDAMGIL	1858
STERLET	1799	ELFQTCFKRIARRG--SCEKQVLLDVTYQM-FQ-NDELHNTARQAVLDRSLLTLTHCSLDALKEFFCTVGDIMGTL	1874
COELACANTH	1787	ELFLQSFKRIARRG--SCDRQVTLDDTVYKM-FC-SEDLRSNTROAIMDRFTLITMLNCSIDCKEFLCKNILDVMTL	1862
HUMAN	1776	ELFQSSFRRIARRG--SCVTQVGLLESVYEM-FR-KDDPRLSFTROSFVDRSLLTLLWHCSLDALREFFSTIVDAIDVL	1851
CAECILIAN	1789	ELFLTSFKRIARRG--NCDKQVALLTVHDM-FK-TENLWNTTRQTIIVDKSLLLIWHCSLDALKEFFCKIIHMTDITL	1864
PLATYBUS	1780	ELFQMSFKRIARRS--GSAKQVALLAVHGM-FL-RDHLSSSTRQAFVDRSLLTLHCSLDALKEFFYRIIVGAMDML	1855
CANARY	1778	DLFQASFKRISRRS--PTDKQVLLDVTYHKM-FQ-SEELLSNAARQAFVDRSLLTLLWHCSLDALRVFFGKIIIVAMDITL	1853
OSTRICH	1748	DLFQASFLIFKIRRL--NSDRQVLLDVTYHKM-FQ-SEELLSNVTRQAFVDRSLLTLLWHCSLDALRVFFGKIIIVAMDITL	1823
TURTLE	1787	DLFQTSFKRISRRS--SYEQVQVLLDVTYHKM-FQ-SEALLSNARQAFVDRSLLTLLWHCSLDALRVFFGKIIIVAMDITL	1862
ALLIGATOR	1745	DLFQTSFKRISRRS--DCNKQVLLDVTYHKM-FQ-SEELLSNVTRQAFVDRSLLTLLWHCSLDALRVFFGKIIIVAMDITL	1820
SOFTCORAL	1777	EEIQIQAFKFIKRL--KLQARKALDICFDV-FTKKDTYRNLRRAAIDKVCVLLRASSTVVFREFYVDHIKIMEII	1853
STONYCORAL	1797	DQIQQSFIAFIQRLhpPQAKAAMDVCLSI-FF-NERDVTQTHSRRAVIERICTITFLKTKSTARRAFYQDQIKLMSVL	1874
ACORN WORM	1802	DLFQASFLIFKIRRL--PADKQKPAVDVAFDV-FH-KENVDYNDIRRAALERVGLPLRLRVDIPITLSTFFISHVQIMNTI	1877
LANCELET	1802	DDIQTSLSRFIKGM--GADRQKPALDIPYGI-FR-REGSFPNEIRRSALERVCLPMLRLVHPALTEFFTDHIREIMDII	1877
SEA URCHIN	1797	DIQKGLSSFAKRL--PSEKQSAANIPFEI-FK-QDNYSKEIRRAAIAQRVCIPLLRQASRDATVTFYKGIHDIISVL	1872
STARFISH	1808	DEIQESLAAFIKRL--PEEKQTAAGVAYQI-FC-QDNYSFKEIRRAAIAERVCIPLRLRQASRDATVTFYKGIHDIISVL	1883
TERMITE	1808	NVTLDRCRGLQTEHQLVGRIGAWNILEPLFVHLESSELESKECVITAAAFPGAV--KTGKE-LISDLTSTRAYKYRSE [4]	1885
SHRIMP	1827	SAPVHGRSDEQHKTLVT-KVGSFMILQIMYKFLRKLFPAGEISINAAFRPGDQ----SGKeLTKELIFRYAAKISKG	1898
SCORPION	1835	KSKRKSNE----IQLVSKIGAFQLIEILYTYLSKEEV-SKESQINCSYKELT-----REATGFATAARKE	1896
ALVINELLA	1790	ELQFSQL--SVSESQMTKLCNFELLEVMSRLTRREVRSKNTINQKCYPKT-dVEGKE-LTAAITKAAHHTKRE	1862
CAPITELLA	1848	EAKPTKAPEHAFEAQLTKSKIGCFELLEVMSRLPNTDVSNDKSSINKSFCBPKI--PDTGKeMNLITKVSNTATKE	1922
SPONGE	1858	EAKLARVTDPLCEQLVHKSCCFQFTEILYTRLPSSLSMSSTVNTAYCNGSP--QTGKE-LTQAITKCHGAKSE	1931
OYSTER	1839	EAKLVK--SGLENQLTKLCCPQLLELMYGRLSKEEDVHSGKSVINNKKFCVGSVnVDTGKeMTQIMRTAHEAKGE	1913
SNAIL	1845	EQLNLAGPESILKTLTKSVCCPQLLEVMSRSLREEVNSLSSEINKKVCFGKP--ETGKeMTQIKIKAANNAKSE	1918
TRICHOPLAX	1835	ETKLVT--ADLENQLISKLGKYLKMLKMYSKLQKDVNTAESIVKAYTGRPT--EDGKE-ITKSIKAAHACKSD	1906
SEA ANEMONE	1847	EAKPQTYDPPGFESQLTKKMGYKILEVMYSRLKQKABLNPSQSSINLAYCPNDN--TGKE-LTKAITKSAHAAKSE	1919
PRIAPULA	1858	EAKVVKLPERQYESQLISKISLKLLELMYACLPKEDVYKGDALGOVFLASRP--AGSKE-LTPVITRLCYDACRE	1931
ESHARK	1859	QARFTKTESSEFDNLQTRKIGCYKLEVTYIRLPKEDVHSGKSVINNKKFCVGSVnVDTGKeMTQIMRTAHEAKGE	1933
STERLET	1875	QARFTKTESSEFDNLQTRKIGCYKLEVTYIRLPKEDVHSGKSVINNKKFCVGSVnVDTGKeMTQIMRTAHEAKGE	1948
COELACANTH	1863	QARFTKSNESAFDQVTKTKGKYLKMLKMYSKLQKDVNTAESIVKAYTGRPT--EDGKE-ITKSIKAAHACKSD	1906
HUMAN	1852	KSRFTKSNESAFDQVTKTKGKYLKMLKMYSKLQKDVNTAESIVKAYTGRPT--EDGKE-ITKSIKAAHACKSD	1926
CAECILIAN	1865	KGRFTKSNELAFDAQIMMKMSYKMLKMYSKLQKDVNTAESIVKAYTGRPT--EDGKE-ITKSIKAAHACKSD	1938
PLATYBUS	1856	KSRFTKSNESAFDQVTKTKGKYLKMLKMYSKLQKDVNTAESIVKAYTGRPT--EDGKE-ITKSIKAAHACKSD	1929
CANARY	1854	NSRFTKSHHTFDQVTKTKGKYLKMLKMYSKLQKDVNTAESIVKAYTGRPT--EDGKE-ITKSIKAAHACKSD	1927
OSTRICH	1824	NSRFTKSNESAFDQVTKTKGKYLKMLKMYSKLQKDVNTAESIVKAYTGRPT--EDGKE-ITKSIKAAHACKSD	1897
TURTLE	1863	KTRFTKSNESAFDQVTKTKGKYLKMLKMYSKLQKDVNTAESIVKAYTGRPT--EDGKE-ITKSIKAAHACKSD	1936
ALLIGATOR	1821	KSRFTKSNETVFNQVTKTKGKYLKMLKMYSKLQKDVNTAESIVKAYTGRPT--EDGKE-ITKSIKAAHACKSD	1894
SOFTCORAL	1854	ENTRFSKATDSVFESQLVSKLCCPKLLALLYARLEKTDVHSGKSVINNKKFCVGSVnVDTGKeMTQIMRTAHEAKGE	1926
STONYCORAL	1875	EAKELKPTDPNFESQVTSKLCCKPFLVILYQFSKSELNLTLESTINKAYVGGDV--KTGKE-LTLAITKAAHAASE	1948
ACORN WORM	1878	EAKQIKVPESSEFTQLVSKIGCFELLEVMSRMTKEELNTPQSKVNIKYCRDSV--KSGKE-MTMALTKIAHAAKGE	1951
LANCELET	1878	GAQPTKAGEASLRQLVTKNKLCCPQLLELMYGRLSKEEDVHSGKSVINNKKFCVGSVnVDTGKeMTQIMRTAHEAKGE	1951
SEA URCHIN	1873	EARLTKNVPAPFENQLVSKICYFELLEVMSRSLKDDLNKSDSALNREYRHGNV--EKGNE-MSTALTKAALGARNE	1946
STARFISH	1884	DAKTIKAPETVFNQVLSKTCPPQLVLMYSRLVKEDLFSMDSAINKAYTND-V--KTGKE-MTQALTKACHAAKSE	1956
TERMITE	1886	NLTGNVQLVELFRSQCAAFNTLVAIISNVKCELRFPTGLLFSENKAK-EVPWGLVNCNKEYALALDWEIPARRKQLV	1964
SHRIMP	1899	ELRHDTAEALRRLCACAAYNAIIVLAVCVQNDLRFYTNFLSANPTKGEVIWECLVDCSRNLEFDVEINFKPASKRRFV	1978
SCORPION	1897	NLEGESITAEALRRLCACAAYNAIIVLAVCVQNDLRFYTNFLSANPTKGEVIWECLVDCSRNLEFDVEINFKPASKRRFV	1975
ALVINELLA	1863	NLQGEVPLELQRQYCAAYNTLIVAVICTQTEIKFYNGFLFSENINMGECGLWDLVDQKQKEYFPPVELQNP--HHKKLV	1940
CAPITELLA	1923	NMNGETLLIPLRRALHCAAYNTLIVAVICTQTEIKFYNGFLFSENINMGECGLWDLVDQKQKEYFPPVELQNP--HHKKLV	2002
SPONGE	1932	DLHGDRTHYETRRQYHCHAYNTLMSVICTQSKPQFPVFLFKEDVVKQGLLWDLNIDCEKQYEFQVDFEAPLKRKQIT	2011
OYSTER	1914	DVRGETSMVELRRQYHCAAYNTLIVAVLSSTQTDKAFYTAFLFKEDVVKQGLLWDLNIDCEKQYEFQVDFEAPLKRKQIT	1993
SNAIL	1919	DLRGETSMVELRRQYHCAAYNTLIVAVLSSTQTDKAFYTAFLFKEDVVKQGLLWDLNIDCEKQYEFQVDFEAPLKRKQIT	1998
TRICHOPLAX	1907	DLRGETSMVELRRQYHCAAYNTLIVAVLSSTQTDKAFYTAFLFKEDVVKQGLLWDLNIDCEKQYEFQVDFEAPLKRKQIT	1986
SEA ANEMONE	1920	DMRGETVAFELRRQLHCAAYNTLIVAVLSSTQTDKAFYTAFLFKEDVVKQGLLWDLNIDCEKQYEFQVDFEAPLKRKQIT	1999
PRIAPULA	1932	DMRGERALLELRQYHCAAYNTLIVAVLSSTQTDKAFYTAFLFKEDVVKQGLLWDLNIDCEKQYEFQVDFEAPLKRKQIT	2011
ESHARK	1934	NMTGEKQLEKRRQYHCAAYNCIMAVVTCIFTEAKFYQGLFSEKAEKNLIFENLLEAHTYVFPVEIEVPLERKKRYV	2013
STERLET	1949	NMAGETQLEKRRQYHCAAYNCIAVIVISCVFTESKFYQGLFSEKPEKNLIFENLIDAKHTYVFPVEIEVPLERKKRYV	2028
COELACANTH	1937	NMAGETQLEKRRQYHCAAYNCIAVIVISCVFTESKFYQGLFSEKPEKNLIFENLIDAKHTYVFPVEIEVPLERKKRYV	2016
HUMAN	1926	NMAGENQLLEKRRQYHCAAYNCIAVIVISCVFTELKFYQGLFSEKPEKNLIFENLIDAKHTYVFPVEIEVPLERKKRYV	2005
CAECILIAN	1939	NMAGETQLEKRRQYHCAAYNCIAVIVISCVFTESKFYQGLFSEKPEKNLIFENLIDAKHTYVFPVEIEVPLERKKRYV	2018
PLATYBUS	1930	NMAGETQLEKRRQYHCAAYNCIAVIVISCVFTELKFYQGLFSEKPEKNLIFENLIDAKHTYVFPVEIEVPLERKKRYV	2009
CANARY	1928	NMAGESQLEKRRQYHCAAYNCIAVIVISCVFTESKFYQGLFSEKPEKNLIFENLIDAKHTYVFPVEIEVPLERKKRYV	2007
OSTRICH	1898	NMAGESQLEKRRQYHCAAYNCIAVIVISCVFTESKFYQGLFSEKPEKNLIFENLIDAKHTYVFPVEIEVPLERKKRYV	1977
TURTLE	1937	NMAGESQLEKRRQYHCAAYNCIAVIVISCVFTESKFYQGLFSEKPEKNLIFENLIDAKHTYVFPVEIEVPLERKKRYV	2016
ALLIGATOR	1895	NMAGESHLLGKRRQYHCAAYNCIAVIVISCVFTESKFYQGLFSEKPEKNLIFENLIDAKHTYVFPVEIEVPLERKKRYV	1974
SOFTCORAL	1927	NMQGETVLELPLRRYHCAAYNTLIVAVLSSTQTDKAFYTAFLFKEDVVKQGLLWDLNIDCEKQYEFQVDFEAPLKRKQIT	2006
STONYCORAL	1949	DMRGETSMVELRRQYHCAAYNTLIVAVLSSTQTDKAFYTAFLFKEDVVKQGLLWDLNIDCEKQYEFQVDFEAPLKRKQIT	2027
ACORN WORM	1952	DIRGESVLELRRQYHCAAYNTLIVAVLSSTQTDKAFYTAFLFKEDVVKQGLLWDLNIDCEKQYEFQVDFEAPLKRKQIT	2031
LANCELET	1952	DLRGETGLLDRRFHCAAYNTLIVAVLSSTQTDKAFYTAFLFKEDVVKQGLLWDLNIDCEKQYEFQVDFEAPLKRKQIT	2031
SEA URCHIN	1947	DCRGETVAFELRRQYHCAAYNCIAVIVISCVQDMKIFYNLFSENHAKQGLLWDLNIDCEKQYEFQVDFEAPLKRKQIT	2026
STARFISH	1957	DIRGETVAFELRRQYHCAAYNTLIVAVLSSTQTDKAFYTAFLFKEDVVKQGLLWDLNIDCEKQYEFQVDFEAPLKRKQIT	2036

Supplementary Figure 3: DNA-PKcs COBALT Metazoa Vertebrate Invertebrate

TERMITE	1965	SIRCOARAQRRETLGFASQS	VRYIPSA[1]	QYLFDSLNLNEDVTLDFD	--STSVVSTEARPG	-----HDEKTP	2027	
SHRIMP	1979	AVRQKLRREAREEGAVVAGT	VQYMAASH	--YLDSSSLREDMSQDFD	n-----NSVVLAMS	---QTEKSSSERVGTGAN	2043	
SCORPION	1976	SVRHENRELNNSKNTLNASS	LKYAPASQ	--YLDSSSLSDVVSQDFD	--SSSELAFSQDMKknkRKEE	IDSNSPNEA	2046	
ALVINELLA	1941	AIRSEHRESENFDSSLPVSN	--YLASQ	--YLDSSSLMDDVVSQDFD	--TVSVQTSSTYTS	---PSSKHKHSRLTK	2006	
CAPITELLA	2003	SIRTSVRDVPDDEPTGPAF	[1]VHYLASQ	--YLAGSSSLTDVVSQDFD	--GSSMVSSADSSF	-----DNQRSRESSIE	2069	
SPONGE	2012	SIRDDLKQSTAAGNSSGSPS	[6]PRYISSQ	--YLDSSSLTDVVSQDFD	---TLPHHHQYGSV	---GGGASTESSSID	2083	
OYSTER	1994	SIRNEVKE--SNQGEADEG	[3]SLHLAS-	QYLADSSLEDLQYDFD	--TATPQMSSEGSPrekLTVRKSSYT	----	2062	
SNAIL	1999	AIRSEMQE--KQS----	DKDG[3]SYHLAS-	QYLFESSLEDLSKYEF	--TVSGSAQNTSG	----iPKTKASLRK	2060	
TRICHOPLAX	1987	SLREQRSRSVSSADEADS	[5]PSYHLS-[1]	QYLADSSLENEISQDFD	n--SSTVQGYSENNSikqIPTRETGDSEKAK	----	2064	
SEA ANEMONE	2000	SIRINARVQSDQVEEALSQG	[2]VRYLSS-	QYLADSSLEEVVSQDFD	--STPVQVNIINYL	-krTKGPDQLGEDSYE	2071	
PRIAPULA	2012	AIRTAVRE---IDRDADQGG	[5]VHYLAS-	QYLADSSLEDLSRYDF	nvSTQIRERGDPRaerkPEGEAEEQE	EAAA	2086	
ESHARK	2014	SIRKEAREAGDGSSE	----	PQYLSQ	SYMADSSLEEMSQDFD	--STGVQSFYSNSQ	---DPRGHAVRSRRKE	2078
STERLET	2029	AIRKEARQGGEGDSDE	----	PHYLSQ	SYMADSSLEEMSQDFD	--STGVQSFYSNSQ	---DPSARAAARGRRRE	2093
COELACANTH	2017	AIRKEARSTIGDLS	----	PQYMSQ	SYMADSSLEEMSQDFD	--STGVQSFYSNSQ	---NRAAAVVHSRRKE	2081
HUMAN	2006	EIRKEAREANGDSG	----	PSYMSL	SYLADSSLEEMSQDFD	--STGVQSFYSNSQ	---DPRPATGRFRRE	2070
CAECILIAN	2019	AIRQEARNANGESDA	----	PHYLSQ	SYMADSSLEEMSQDFD	--STGVQSFYSNSQ	---DPTAAQFHSRRKE	2083
PLATYPUS	2010	AIRKEARVNDNSDE	----	PHYLSL	SSMADSSLEEMSQDFD	--STGVQSFYSNSQ	---DVKSTGYHFRRE	2074
CANARY	2008	AIRKEARDAGNSQDE	----	PKYLASS	SYMDSSLEEMSQDFD	--STGVQSFYSNSQ	---DVTASSTRFRRE	2072
OSTRICH	1978	AIRKEARSTIGDLS	----	PKYLPAS	SYMDSSLEEMSQDFD	--STGVQSFYSNSQ	---DVTASSTRFRRE	2042
TURTLE	2017	TIRKEARDAVNRDSD	----	PQYLPAS	SYMDSSLEEMSQDFD	--STGVQSFYSNSQ	---DPTASSIHRFRRE	2081
ALLIGATOR	1975	AIRKEARDVNGGPD	----	PQYLPAS	SYMDSSLEEMSQDFD	--STGVQSFYSNTQ	---DPTATSAFRFRRE	2039
SOFTCORAL	2007	SIRKEARATVNMSSSENYEHG	[2]LRYLSS-	QYLADSSLECEVSQDFD	--STPIQA--LSQS	-estEQDIAGGENSGT	2076	
STONYCORAL	2028	--RMQARIPSPKENS	----	[2]SAGRTGL[7]	QYLADSSLEEDISQDFD	--SSPIQVHSGTEA	-rqPLYKLNESSSTAE	2101
ACORN WORM	2032	AIRKEVRD--ASEEDLQDS	[9]VRYLSS-	QYLADSSLEEMSQDFD	--NTGQLYWHNTL	Cmsi---FACMLHVLP	2106	
LANCELET	2032	SIRQELRE--QDSPEA	----	[2]SRYMQS-	--YLAGSSLEDISQDFD	--TSGTQVKHSQT	FsstQERYSQASQGSRR	2097
SEA URCHIN	2027	AIRTOARG--TNTPEESG	--[4]PAHYLSS	QYLADSSLEEDVQDFD	--SSSRHFGSSMSsq	-rDGSQGSQGSQR	2097	
STARFISH	2037	SIRNQDQDTRGSSSQSDS	[8]GRYLS-	T--	QYLADSSLEEDISQDFD	--SGGVQFNASIDkq	-SLSRQSSVPHIK	2114
TERMITE	2028	-KE---SGAESTEV	ILESDDLNMHECMA	TLGCVIEHMVDQGISPTPDAETKDA	--ALPPWMESMRKCLS	--DYSQPR	2096	
SHRIMP	2044	EMGg---	VLMFVHMDSQYNGHEVMANL	TVINHMVDAEIMVLHKGDTVPKATDVPQWMTLVQKQLD	--SADTPR	----	2113	
SCORPION	2047	KDD---	DLVSNITVELEIDDLNQHECMNSL	TMLVQHMEKIQL	----LSSSPK--EIPKWL	DLNLCCKLE--DYSVHR	2111	
ALVINELLA	2007	[7]DVLdteVTVQGDYVE	IEMDELNKHCEMPL	IGLKLHMARNNITPSVTKGETPA	--SLPTWMSN	IKNKLQ--CPSSTR	2086	
CAPITELLA	2070	[1]VDP---	VVLKEHYIEMEDALNQHECMAL	SALLQHKLNQITPEVEKGSKS	----	EMPTWKNLHDKIK--NSDTQL	2139	
SPONGE	2084	[5]SQEassYVVEE	--QLEEDLNIHECMT	PLMKLDHMIINKITPAPSGDSP	----	EMPPWMTPLHKRMT--DSRTRG	2157	
OYSTER	2063	[3]DDTdtkVMVDYVE	LEMDELNQHECMANM	ALLKHMQRAKIPLVSEGVVP	----	ELPAMWKNLNDKLR--SPRTHN	2137	
SNAIL	2061	[3]YGGdnkVRLDGDYVE	LEMDELNSHECMA	PLVALLKHIIKNNIFPAAQSDASSQ	----	DMPQWVFLHDKMTknTGSDDL	2138	
TRICHOPLAX	2065	TTI----	NKFADEE	LELDDLNKHCEMALLTLLDHMAVNKINPAIEKDTTPS	----	EMPSWVALRKKAS--DHTNTR	2132	
SEA ANEMONE	2072	IGLg---	D-----	VEMDELNSHECLTKICSLTLMKESNI	SPQDKGALP	--DMPSSALHKKLT--NFETHL	2133	
PRIAPULA	2087	[4]EESgsATLADYVE	MEMDELNQHECMA	SMVALINHLATVVCPIQA	--ASSPA--HMPAWMELLHGKFS	--HVEITPL	2161	
ESHARK	2079	QAE---	SVVQSDVLEEMDELNQHECMA	PMIALINHMQRNNITPQVEEGKTPQ	----	ELPAMWFLHGKLG--NSSIPL	2149	
STERLET	2094	RVE---	SLVQDDVVELEMDELNQHECMA	SMTALLNHMQRNNITPKVDEGTVPA	----	DLPPWPKFVHGKFG--NASTHL	2163	
COELACANTH	2082	RTB---	SVVQDDVMEFEMDELNQHECMA	AMTALLNHMQRNNITPKVDEEGTVPA	----	ELPPWPKFLSHKLA--NPATPL	2151	
HUMAN	2071	QRD---	YVHDDVLEEMDELNRHECMA	SMTALLNHMQRNNITPKVDEEGTVPA	----	DLPPWPKFLHGKLG--NPVPL	2140	
CAECILIAN	2084	HPE---	FTVQDDVMEFEMDELNQHECMA	AMTGLIKYMQKTIPTPKVEEGTVPA	----	DLPPWPKFLHGKLG--NTSTPL	2153	
PLATYPUS	2075	YRD---	PVTQSDVLEEMDELNQHECMA	TMTALLNHMQRNNITPKVDEEGTVPA	----	DLPPWPKFLHGKLG--NPLGAL	2144	
CANARY	2073	PTE---	YKVLNDEMELEMDEFNQHECMA	SMTSLIKHMERNQITPKVDEEGTVPA	----	DLPLWPKFLHGKLG--NPSVPL	2142	
OSTRICH	2043	PTB---	YMALDDDTVELEMDELNQHECMA	SMTLLKHMQRNNITPKVDEEGTVPA	----	DLPLWPKFLHGKLG--NPSVPL	2112	
TURTLE	2082	PTB---	SMDDDLMELEMDELNQHECMA	SMTLLKHMQRNNITPKVDEEGTVPA	----	DLPPWPKFLHGKLG--NPSMPL	2151	
ALLIGATOR	2040	STB---	SMVDDDEMELEMDELNQHECMA	TMTLLKHMQRNNITPKVDEEGTVPA	----	ALPPWPKFLHSLKLG--NPSVPL	2149	
SOFTCORAL	2077	PASpkESDSISSE	LEMDELNRHDCMT	TVGLINHLVKNKISPPQEQKEAN	----	EMPPWMSYLHKKLS--HSSSEL	2109	
STONYCORAL	2102	QTD---	DWYEVSEDTLEMDDLNRHESMA	KMISLLKHLVKKISPEQVKDVPP	----	DMPAWMAPLHKKIA--SSSTHL	2171	
ACORN WORM	2107	[4]SLLppsAFVKGDYLE	MEMDELNLHCECMS	NMTALLKHMQRNNITPKVDEEGTVPA	----	ELPGYMSYLQKCLS--GPSNTP	2183	
LANCELET	2098	[4]QQQdssVNIHGDFLE	IEMDELNQHECMS	MSAVALKHMQRNNITPKVDEEGTVPA	----	DMPWMSCLNKKLG--GSSTHK	2174	
SEA URCHIN	2098	[7]QDSkpVSPGGEYLE	EMBEDALNQHECMA	AMTGLVLMQRNNITPKVDEEGTVPA	----	EMPPWMSGLQKCLS--SQSTEH	2177	
STARFISH	2115	[4]NEBtpVTVVQGEYIE	MESDALNQHECMA	SLTAVLKHMQANKITPEIPEGKAS	----	EMPPWMSLQKCLT--SQSTHV	2191	
TERMITE	2097	NIRLFLKILINLVESKFPY	AHHMNSILKAIT	DGVV	--GRAPNYLLSDTVAMLADWCRKT	TSLPAKSDHHL-V	2167	
SHRIMP	2114	NVKLFLLRVMNNA	RIPEYAAHFVSTILTCV	DGTI	--GDKINYFFCDVMVMVWGSKA	VPQDVTMGRNI-V	2184	
SCORPION	2112	NIKLFLTKFLINNAE	IFKPYAVFLQLPLINLIL	NATF	--GREINYLFLDLMLVLLSWSSIA	IPEDSSIGRHA-A	2182	
ALVINELLA	2087	NTRLFLVKLIINTE	EVFKPYAKDWFGLVQIIT	RGDL	G--TNGINYMISDLTITLLSWHTVA	IPEDNSADKAM-A	2158	
CAPITELLA	2140	NIRLFLAKVILNG	ESVFRPYASFQPLVALAT	--NM	G---GLNYFSLDIIVTLLSWHEIA	IPETTVDIAM-T	2207	
SPONGE	2158	NIKLFLVRLITNR	PKIFQPYAKHWLPLVTFQIL	SGDS[9]	GgENGLDYFTVDAIATMLSWSSIA	----IEDRFL-G	2235	
OYSTER	2138	NIKYFITKLIINT	AEIFRYPYARDWIRPLTQIIL	SG--	L--FTGLNYFVIDVITMSHWQVA	IPQDVTEDRAM-S	2207	
SNAIL	2139	NIRLFLAKLIINT	SEIFQPFARLWLRPLCQIIL	STSL	C--DNGINYFIMDLLVTLMSWSSIA	TVAPQNSSTERAM-A	2210	
TRICHOPLAX	2133	NIKLFLIAKLIINR	PKIFRYPYAKFWLPLIQLIV	-EGK	E--SDGIHYFIVDLMIILLSWADVA	IPKDV--DEILqA	2202	
SEA ANEMONE	2134	NIQLFIAKVIINQ	SQVFEYARFWSPLMELIL	[4]EEGE	N--KRLNYFVVDLLVTLWSWATTA	IPEDSYGRHL-A	2209	
PRIAPULA	2162	NVRVFIARLVVLC	AHAFRCPAASWLAPMLHLV	NGNC	GVAIAIHSLTADVVVVLWSWTPV	ARPQDNMTERSL-A	2234	
ESHARK	2150	NIRLFLIAKLIINTE	EEVFRPYAKEWLGPLLQVIV	SGNN	G--GDGIHYMVVEIVVTVLSWTSVA	TPKGNMKDEIL-A	2221	
STERLET	2164	NIKLFLIAKLIINTE	EEVFRPYAKHWLGPLLQVIV	SGNN	G--GEGIHYMVVEIVVTVLSWTSVA	TPKGNTRDEIL-A	2235	
COELACANTH	2152	NIRLFLIAKLIINTE	EEVFRPYAKHWLGPLLQVIV	SGNN	G--GEGIHYMVVEIVVTVLSWANIA	PAKGNTRDEIL-A	2223	
HUMAN	2141	NIRLFLAKLIVINTE	EEVFRPYAKHWLGPLLQVIA	SENN	G--GEGIHYMVVEIVATILSWTGLA	TPTGVPKDEVL-A	2212	
CAECILIAN	2154	NIRLFLIAKLIANT	EDVFRPYAKQWGLPLLQVIV	SGNN	G--GDGIHYMVVEIVVTVLSWANVA	TAPAGLAKDEIL-A	2225	
PLATYPUS	2145	NIRLFLAKLIANT	EEVFRPYAKHWLGPLLQVIV	SGEN	G--GEGIHYMVVEIVATVLSWTSIA	TPTGVTKDELL-A	2216	
CANARY	2143	NIRLFLIAKLIINTE	EDVFRPYAKHWLGPLLQVIV	SGNN	G--GEGIHYMVVEIVVTVLSWTSVA	TPKGNIKDEIL-A	2214	
OSTRICH	2113	NIRLFLIAKLIANT	EDVFRPYAKQWGLPLLQVIV	SGNN	G--GEGIHYMVVEIVVTVLSWTSVA	TPKGNIKDEIL-A	2184	
TURTLE	2152	NIRLFLAKLIVINTE	EEVFRPYARQWGLPLLQVIV	SRDN	G--GEGIHYMVVEIVVTVLSWTSVA	APKGNIKDEIL-A	2223	
ALLIGATOR	2110	NIRLFLAKLIVINTE	EEVFRPYAKHWLGPLLQVIV	SRDN	G--GEGIHYMVVEIVVTVLSWTSVA	SPKGNVDEIL-A	2181	
SOFTCORAL	2150	NVRLFLIAKLIINTE	PEVFEYAKFWLDSLMELIL	LPTF	K--NSLNYFVIDVITMSHWSSV	TIPEDSYSSRRL-T	2221	
STONYCORAL	2172	NIRLFLIAKLIINTE	AKIFEAHAKFWNPLMELIL	[4]TEPA	G--TEGINYFIVDLVTVLSWSTAI	IPEDSHNDRHL-A	2247	
ACORN WORM	2184	NVKLFLIAKLIINTE	EEVFRPYAKFWLAPLMEWIL	GGQT	G--GDGIHYMIGDIVVLMVLSWATTA	IPEDSAMGRAL-A	2253	
LANCELET	2175	NVKLFLAKLIVINTE	EEVFRPYARFWSPLMELIL	RGEA	S--GEGINYFIVDLVTVLSWGPVA	IPEDSAMGRAL-T	2246	
SEA URCHIN	2178	NIKLFLIAKLIINTE	EEVFRPYARFWSPLMQFLA	GGQQ	G---GINYMLDMLVMLSWSTVA	PE---DNRL-A	2243	
STARFISH	2192	NIKLFLIAKLIINTE	EEVFRPYARFWSGLLQVILI	SGNT	G--GEGIHYMVVDVVVLLGWVVA	PE---DKRL-A	2259	

Supplementary Figure 3: DNA-PKcs COBALT Metazoa Vertebrate Invertebrate

TERMITE	2168	SQLLYLLISKVHDDRDRVFKHNLELIRTVVLELWKNPFDIPVQLLYDMIMKH--RKDPTVsepGIQVAAILANRLEPWS	2245
SHRIMP	2185	GRVLYRLCMNTPQTRADIFKYNLDVVRVSVVECKWSLLTPVYTVIYSLMEVKGDAEREVBA---GLQLLGIILANGLPPYT	2261
SCORPION	2183	SGLLEFLMSKCFHIRRDRVFRNNLEMIKTVQVCWKERLDIPTIYIFESMRNLDTKVKDNIV---GIQLFGIVVSNGLDPPYQ	2259
ALVINELLA	2159	CQLLKVLVASCHHDSQQILKNNLELLKVLVEVWKPRLVPTNIIYENFSDYDLKTKRNM---GIQMTGVILANGLSPYR	2235
CAPITELLA	2208	SHLVKIVYQNCYHQNRQIMRNNLEVLKTLVEAKWSTRIPTQDIYENFIDREDKGRKRVV---GLQIVGVFLANGLSPWQ	2284
SPONGE	2236	SQLEIYMLRSNHNKRSILRNNLEIVRTMVELWKKDIDIPTRVLYDQFNSDKSTVSNLS---GIQLVGIIVANGLNPPYD	2312
OYSTER	2208	SRLVEFVMGYFYNDTRPVYRNNLELLKTLQVWKRDEIPYNIIVYKHLKQDDETKKESCV---GIQLMGVVLSAKFPFYA	2284
SNAIL	2211	SRLVEFLVVRNHHETRAIRNNLEMLKTLLECWKDCIEIPYQEVYNQLKMPDPSKSSLI---GIQLVGVIMTNCNYPYQ	2287
TRICHOPLAX	2203	NRLMEFLMRNAFYPNRSVLRNNEIEIKTAVELWKNHIEIPYRIYKNFSGPKDKKDNST---GIQCLGLVAVANGLSPYR	2279
SEA ANEMONE	2210	SRLQVTMRTRHHENRVAVKNNLEIVKTMVEVWRERVTVPKVIYEALSNPHDKKDNAT---GIQLLGVVLANKIHPPS	2286
PRIAPULA	2235	SRLLEFLMRNARHATMVFRRNNEIEIKTLVECWDRDVPVQVIYENMCAGDITMRDNSV---GVQLLGVVAVANGLNPPYS	2311
ESHARK	2222	NRLLEFLMKNSFHEKTAVFRHNLEIKTVEVCKWDCLSVPSYSLIFSRFSSDTPNSKDNV---GIQLLGIIVLANGLSPYV	2298
STERLET	2236	NRLLEFLMKNAFYDKRAVFRHNLEIKTVEVCKWDCIAPVYSLIFDRFSGKDPNSKNSV---GIQLLGIIVLANGLNPPYD	2312
COELACANTH	2224	NRLLEFLMKNAFYDKRAVFRHNLEIKTVEVCKWDCIAPVYSLYQRFSGKDPNTKDNV---GIQLLGIIVLANGLNPPH	2300
HUMAN	2213	NRLLEFLMKNVFHKRAVFRHNLEIKTVEVCKWDCIAPYRILFEKFSGKDPNSKNSV---GIQLLGIIVMANGLNPPYD	2289
CAECILIAN	2226	NRLLEFLVTHSFHEKRAVFRHNLEIKTVEVCKWDCIAPYRILFIFERFSGNTNSKNSV---GIQLLGLIIVANGLNPPYD	2302
PLATYPUS	2217	NRLLEFLMKNVFHKRAVFRHNLEIKTVEVCKWDCIAPYRILFIFERFSGDPTKDNV---GIQLLGIIVANGLNPPYD	2293
CANARY	2215	NRLLEFLMKNAFHKRAVFRHNLEIKTVEVCKWDCIAPYSLIFQRFSSGDPDKDNV---GIQLLGIIVANGLNPPYD	2291
OSTRICH	2185	NRLLEFLMKNAFHKRAVFRHNLEIKTVEVCKWDCIAPYRILFIFERFSGDPTKDNV---GIQLLGIIVANGLNPPYD	2261
TURTLE	2224	NRLLEFLMKNVFHKRAVFRHNLEIKTVEVCKWDCIAPYRILFEQFSGDPTKDNV---GIQLLGIIVANGLNPPYD	2300
ALLIGATOR	2182	NRLLEFLMKNTFHQKRAVFRHNLEIKTVEVCKWDCITVVPYRILFIEQFSGDPTKDNV---GIQLLGIIVANGLNPPYD	2258
SOFTCORAL	2222	SRLLEYLMECTNHPTRSIFKNNLEIKTVEVWKEIDVPYKLIYERFNSAVMTKNSV---GIQLMGVIVANKITPPK	2298
STONYCORAL	2248	SRLLEFLMSRTRHRSLFRNNLEIVKSVVEIKWSILHVAEVIENSFSDPVPKKNVAV---GIQLLGVVAVANGLFPYT	2324
ACORN WORM	2254	SRLVEFLMHHTHSNRQVLRNNEIMVKTVEVWKRDEIPVSRVIFEFASGDKPKKENAT---GIQLLGVILSNQLPPYR	2330
LANCELET	2247	SRLLEFLMANAFHKRAVFRHNLEIKTAVECWKTRVVEPTKVIHQDLQCGSDASKANSV---GIQLLGVVAVANGLNPPYD	2323
SEA URCHIN	2244	SGVLFRLMKNSYHERKAVMKNLEVIKTLVECWKEIISVPTSVIYRIIATPDPDKDSSV---GIHLGLVILANGLHPLS	2320
STARFISH	2260	NRLLEFLMHFCHHSNRQVLRNNEIMIKTLVECWKEIISVPTSVIYRIIATPDPDKDSSV---GIQLLGIIVANGLHPLD	2336
TERMITE	2246	STGKl----QFLRALLRNIDT-EKRSIFQSSAEVAGMALELLAANGSGMLEGD[2]EPLSGIVDKLNLTKDQs---KDK	2315
SHRIMP	2262	VDSEt---EKKRCSLVIRLLGahYASVYGAAEVMGLLKYTSQ-KDGSVEAL[1]---DAVVKRVTELVTKm---QQQ	2329
SCORPION	2260	NTSR--IDKISYKTLTVNLKN-KYKEIYESASEVCGMSMKYYP-KDDVYSE -FKIKVKTEISSLNAK----DQ	2326
ALVINELLA	2236	PNSG--VDKDRFYKNAKMNQH-TSKAVYMSAEVVGMAKHMTE-TEKEEDDK[4]EPIFDHISSSLIGFQSN---KPRD	2309
CAPITELLA	2285	PDAE--VSKDRFYQYLAMNMQ-PDKQVYASAEVVGMAKSSLQNT-TESDKEWC[1]AYGDNIQKMLLGIHGN---KPPQ	2355
SPONGE	2313	TNTAgsLDQGLYKYIFVNNLTF-KYKLIYAAAAEVLGMKMRMAESYDPPFLDR[1]---EMVGEQLFKLSQPLekSSEK	2386
OYSTER	2285	PTAP--VDQEKFFTTVAQYMRN-RYKAVYATAAEVVGMIFFKHLAE-KDRQTEGT -FHDVYVNLMMNSLQ--q-sNPGN	2353
SNAIL	2288	PSAS--VDRNRYFTTLASSMTN-SSKMIFAAAAEVVGMYFAYLAD-KENETDGO -FHSVHVESVLGKVA-----PHN	2353
TRICHOPLAX	2280	YDVE--VDE---MLATAENLQF-KYKEVYEAVAEVLGMKMLHLS-VKKELEG -PIFDYVTQHLSSMVSAGrmDVAR	2348
SEA ANEMONE	2286	PDSS--VDENRYFYTAISDNLTF-KYKDVHAAAEVVGMLMKYLIIE-ERKVTEC- SLIALVEAKLSPMATKggkDIGK	2358
PRIAPULA	2312	HTTA--VDSEKFFQALVRCLAN-KYKEVYAAAAEVLGMLLHRMVEEEDDEAEGA -LRDAVVTAMSTLH--a-dAKNQ	2381
ESHARK	2299	PKCE--IGYERYFQRLVYNIISLTRYKEVYAAAAEVLGMLLHYFAE-NEKQVDDG- LVHDLIAKELKQLQSS---KEDK	2368
STERLET	2313	PKCG--IDSESYFQALATNISFgRFKDIYAAAAEVLGLIMQYLAKE-NEKQLEG- PIFDPTVKELKHLQNT---KEDK	2382
COELACANTH	2301	PTCS--IDMESYKALANNSLFTRYKEVYAAAAEVLGLVLYRAE-KEKELGG- PIIDSVVRELKQLQSI---KEDK	2370
HUMAN	2290	PCGG--IQSSEYFQALVNNMSFVRYKEVYAAAAEVLGMLLRYVME-RKNILEE- SLCELVAQQLKQHNT---MEDK	2359
CAECILIAN	2303	PKCG--IDVERYFQALANNIALTKYKDIYAAAAEVLGLALHYVAE-KEKTELEG- PLFDCVVKELKQHNA---KEDK	2372
PLATYPUS	2294	PKCG--IDSARYFQALANNSLVKYKEVYAAAAEVLGMLLQYVSE-KETMLD- SICEILIVKQLKQHNS---REDK	2363
CANARY	2292	PKCE--IDRVRYFQALTSNMLKYREVYAAAAEVLGLALQYIAE-RENILED- PVYDCVVKQLKQHNT---QHDK	2361
OSTRICH	2262	PKCE--IDRVRYFQALISNMLKYREVYAAAAEVLGLALRYVAE-RENILED- PAYDCVVKQLKQHNT---QDDK	2331
TURTLE	2301	PKCE--IDSVRYFQALANNSLRYKEVYAAAAEVLGMLLQYMAE-KENIFEG- PVYDCVVKRIEQHNT---KEDK	2370
ALLIGATOR	2259	PKCG--IDSTRYFQALVNNMALKYREVYAAAAEVLGMLLRYIAE-KENITEG- PIYDCVVKQLKQHNT---KEDK	2328
SOFTCORAL	2299	PCGG--VDEKRFYQDLVKNLSF-KYKDVHAAAAEVLGMLLKYLSE-END-KESC[1]GLSGLLNEKLSMT---kDLK	2367
STONYCORAL	2325	SDST--IDEDRFYGLVNNLTF-KYKDVHAAAAEVLGLMMQLAK-VKKIFDG- PLHDMVQGLKLSLVNRakpELDK	2396
ACORN WORM	2331	DTCC--IDKDRFYTTLSANLSF-KYKDVYAAAEVVG-VMKYMAE-KEKVTDGT -FHDNVFREISSQ--s-sRPEV	2398
LANCELET	2324	PSTsgnIDREQFFSAVAKNLQLTRYKDVYAAAEVVGMLMKYMAE-VEKVTEGS -FHTQVERYLLPLQ--v-nQQDV	2395
SEA URCHIN	2321	PTCD--VDADRIFYSALASNIDN-RYKAVHAAAAEVLGMAMKQMAE-NDKITDGR -LHEVTYKELSQLHLSg-gKEVI	2391
STARFISH	2337	KASD--IDEEFYAALSYNLKN-RYKMHAAAAEVLGMAMKQKAD-VDKVTDGF -LHSIVTSELTKI--Se-ikPDV	2405
TERMITE	2316	FLTCLFAVQYYPRIVDA -FMNHVLFHLPKTYGIFRTMCKLIVYSRLEILgDDTYAEMKSKNLFKTLSDRDPDQQN	2390
SHRIMP	2330	GLTCIYNIHKHYPFVFR -LINKLNLPLKLYGHRKNVLECLIAHSATM-EDIYHLKQNLLDILAKKEASTQL	2403
SCORPION	2327	YLTCLYKINHTHPIFIDS[1]-FLNKILYMLPNEVHGLFRKQILEIINSHVENI-ENAFELKNQNLNMLHRDESIFQ	2401
ALVINELLA	2310	FISCVYGMQLHPPTIADG -FLAKVLFILPKVHGFEKTHSLEILQNRISQI-DNAFLEMKSGISDILSRNEANQH	2383
CAPITELLA	2356	FLTCVHCIQKHFSAFVER -FIHKVLFMLPGLYGVFRYALBIIAAGIENI-EGAFVEIKNNKIGILRERDELSQL	2429
SPONGE	2387	FITCLHKITLCKYKNIIVPR -FVEKLLFLLPSLQGVFRSSCLEILDTQADVQ-PQFYLKLDKGFHTMI SHRDEATQT	2460
OYSTER	2354	FLLCIHRMHLHYPPIADR -FMNRLFLVLPNLHAEFRNRNLEIVLTRIDTL-ENVVYELKSGKGLAFILTHRDEATQV	2427
SNAIL	2354	FLLCVHCIIHRHYPPMADR -FLNKLFLMPLGLHGEFRVQCLEVIMGCIEQL-DDAFRELQSKGLLNLFRDEDTQI	2427
TRICHOPLAX	2349	FILCLYRVQLHYPIIAD- RFVNKVLFLMPSLYGFEKTKCLEIILARADHI-KELYTELNRNGLKDMFLHRDESKOQ	2422
SEA ANEMONE	2359	FITCVHRLQLNYPRIVD- RFMKHIMFHLPTIHGVFKAQCLEIVLSRVSDI-PDLFTELRSKGLNVMFHRDEGVQV	2432
PRIAPULA	2382	FIVCLQKMTLHYPAIADR[17]RLMSKLLFMLPSLQGSFRSQCLEVILTRVAHT-QNLFLELKSGLFLGMITHRDEATQL	2473
ESHARK	2369	FIVCLSKIVKNYPPFADR RFLNQVFYLLPKLHGVLKTHCLEVVMHRAETI-IDIFQELKNKNFVQIMSYSDERQR	2443
STERLET	2383	FVECLSKVKNYPPFLVD- RFLNAVFLFLPKLHGVLKTHCLEVIMHRAEVE-TDIYQLKSKDFQAQIMSHRDEMRQR	2456
COELACANTH	2371	FIVCLSKIVKNFALLAD- RFMSVVFLLPKLHGVLKTHCLEVVMHRAEVEI-PDIFLQKSKDFIQLMNRDARQR	2444
HUMAN	2360	FIVCLNKVTKSPPLAD- RFMNAVFFLLPKLHGVLKTHCLEVVMHRAEVEI-TDYFLQKSKDFVQVMRHRDDEQR	2433
CAECILIAN	2373	FIMCLNKVKNFSPPLAD- RFMTVVFLPKLHGVLKTHCLEVVMHRAEVEI-PDYIQLKSKDFNQIMSHRDDRQK	2446
PLATYPUS	2364	FIVCLNKVKNFSPPLAD- RFLNAVFFLLPKLHGVMKTFCLEVVMHRAEVEI-TDYIQLKSKDFQAQVMRHRDDEQR	2437
CANARY	2362	FIVCLNKVKNFSPPLAD- RFMNAVFFLLPKLHGVMKTYCLEVIMHRAEVEI-PDLHLQKSKDFIQLMNRDDEQR	2435
OSTRICH	2332	FIVCLSKVKNFSPPLAD- RFMSAVFFLLPKLHGVMKTHCLEVIMHRAEVEI-TDLHLQKSKDFIQLMNRDDEQR	2405
TURTLE	2371	FIVCLNKVKNFSPPLAD- RFMNAVFFLLPKLHGVLKTYCLEVVMHRAEVEI-TDYIQLKSKDFIQLMNRDDEQR	2444
ALLIGATOR	2329	FIVCLNKVKNFSPVAD- RFINAVFFLLPKLHGVLKTHCLEVVMHRAEVEI-TDYIQLKSKDFMQVMNRDDEQR	2402
SOFTCORAL	2368	FILCVHQLQIHPPYIVD- GFINQILFVQVHVAQFKTLCLEIILSRVGI-PNLFLELTKGFLNLTTHRDEATQV	2441
STONYCORAL	2397	FITCVHKLKNYPPIADR- RFVNQILFLLPSVHGDFKSYCLEILCSRVHI-PNLFTELKGRGLKEMLSQRDDGIQI	2470
ACORN WORM	2399	FITCIYKVOQLYKFPTR- -FINKLFLMPLQIHGQPKTYALEVVLGRVDSI-DKIFLEMKNKRIEMLRHRDETITQL	2472
LANCELET	2396	FLTCVHKIHLHPPFADR- -FVSKLFLMPLKHLGFRTHCLEVIRGRVNI-DNLFLELTKRNLFLMGLTHRDDGLQA	2469
SEA URCHIN	2392	FITCLHKIHLHYPPFTR- -FMNKLFLMPLSHHGQPKTECLQITARIEHI-DNAFLEMKNKILALLTHKDEADQL	2465
STARFISH	2406	FVTCIHKIHLHYFPEADR- -FTNKLFLMPLSHHGQPKTLCLEVVASRVSHI-PNIFLEMKSKGIVELLTHRDEGTQL	2479

Supplementary Figure 3: DNA-PKcs COBALT Metazoa Vertebrate Invertebrate

TERMITE	2391	LALSIVHKMVPHLKPEQLEELVHE-ICKFETQRSVKCRSVMYBILKWIYDHC-----QDi--GGVLEIEAKGILLK	2458
SHRIMP	2404	VALQLVNAVMPRLTPSQQLYFMPG-VVAFASHAPASCRTMYDVLFWVYDNF-----SNNDTE--GGHQLSEQARGVLLR	2475
SCORPION	2402	SSLNIIQKLLKELDIKMLNVFPI-ISKVHKSABETICRKYMYEIMMHAYEKF-----NTKNGik-EKEISRYAKEMLLH	2473
ALVINELLA	2384	AALRLVKGLCNQKPKPAEILYLLPV-LTEFASHPSASCRAQMYNMLMWIYDNY-RDDGDTDEQ-----IIQSVKETLLR	2455
CAPITELLA	2430	MSLKIIRLLEKLEASQLLYLLPA-ICEISDLSSVLCRRMYQLMWCYDNY--KDEAQSESr---DEIITLTKDVLRLR	2502
SPONGE	2461	ASLSIVQKLLVQLTNDQLSEIVPILIASFSKHGSIQCRIVLYNLMRVYNKLCtDDQSESDDsv---KMIRSIIRDQLLL	2537
OYSTER	2428	IALKIVKSIQSLQPSVSELLPL-TCGFSVSPSPICRQVMYDILMWIYDNY-REDESET--A-----DTIMQQTKESSLK	2499
SNAIL	2428	VALGIVNAVMPKLSATLQTFLLPA-ITGFSNHPSVTCRQIMMKILMWIYDNY-RDNESKE--G----QEIMKVQTESLLQ	2499
TRICHOPLAX	2423	VSLDLVRAMLKNDISQILYLAEI-VATFKTNPSAACRQKMYGIFMWIYDTF-RQEDKNDKDE---TKQLINFCKDQLLQ	2496
SEA ANEMONE	2433	ALLKIIQGLLEKLMSEIEYVVPV-IATMATSSSTACRELIIYDIFMWVYDTY-RSDETFRNE--egSEEILATAKDYLLR	2508
PRIAPULA	2474	ASLHITNALLSSLSPEGLLFLPA-VTSGTHPRAPCRQLMYDILMWVYDYSV-RDSEGEeE-----DKLASLARDSLLO	2545
ESHARK	2444	ICLDIVYKIIAKLKAEEVKVFLVP-VIAFISHPSVPCRERMYDILMWIYDNY-RDAESQSDPD---SKAVFVTTKDTLLQ	2518
STERLET	2457	VCLDIVHKILAKLKFVVKELLIS-VTAFITHTPSVPCRERMYDILMWIHDNY-RDPESQSDSV---STEVFNLAKEITLLO	2531
COELACANTH	2445	VSLDIVYKMLKPKPELRELLNP-VTGFISHPSVPCRERMYDILMWIHDNY-RDPESQANNE---SREVFLKASEVLLQ	2519
HUMAN	2434	VCLDIIYKMKPKLKPVELRELLNP-VVEFVSHPSVTCRQMYNMLMWIHDNY-RDPESQDND---SQEIFKLAKDVLIO	2508
CAECILIAN	2447	VCLDIIYKMLKPKPELRELLNP-VVTFSSHPSVPCRERMYDILMWIYDNY-RDPESQANDD---SQEVFSRANDVLLQ	2521
PLATYPUS	2438	VCLDIIYKMLKPKPELRELLNP-VVEFISHPSVPCRERMYNMLMWIHDNY-RDPESQADEE---SREVFLKAKEILLQ	2512
CANARY	2436	VCLDIVYKMLKPKPELRELLNP-VTGFISHPSVPCRERMYDILMWIYDNY-RDPESQADD---SREILKVAKEVLLQ	2510
OSTRICH	2406	VCLDIVYKMLKPKPELRELLNP-VTGFISHPTVPCRERMYDILMWIYDNY-RDPESQADGD---SQEVFLKAKEILLQ	2480
TURTLE	2445	VCLDIVYKMLKPKPELRELLNP-VTGFISHPSVPCRERMYDILMWIYDNY-RDPESQAEeE---SQEVFLKAKEMLLO	2519
ALLIGATOR	2403	VCLDIIYKMLKPKPELRELLNP-VTGFISHPSVPCRERMYDILMWIYDNY-RNSESQADE---SQEVFKVAKEMLIO	2477
SOFTCORAL	2442	ACLRIILGRLSQMSVGDIIQTLLPS-VTDFLSSKSVACRGLMFDILWIYDTY-RFDETFKNEDEsegSEdVLCRTKNVLLQ	2519
STONYCORAL	2471	GVLRILKMLKLPITPELKFIFPL-LTSFVSHPLNLCRDLMYDIFWIYDYSV-RAEAFQAE--egSADILADAKDHLLO	2546
ACORN WORM	2473	VSLKIVNSMLKPKPELRELLNP-VVFSKHLSPACRETYMIDILTWIYDNY-KDEESS--TA---A-EVLSMTKEILLQ	2544
LANCELET	2470	IVLQIYVALLQKLVKVELLYLLPS-VAAFASHAPECRRTMYDILMWIYDNY-REEASQQAESA---G-RVLTAKDCLLO	2543
SEA URCHIN	2466	VSLKLVDMGLPKPELRELLNP-VKDFVSHPSVPCRERTMYSILMWIYDNY-RDEDKREGQD---GDEALSIKADTLLQ	2540
STARFISH	2480	VSLKLVNAMLPNPKPELRELLNP-VRTVFNLPSVPCRERMYDILMWIYDNF-RDEESRTEDG---ADDLCMAKDTLLQ	2554
TERMITE	2459	GLRDDDPLQDSIFeYfnwSDAQORDASTDRLLFLITLDLYCPATEHIF	2534
SHRIMP	2476	AVKEEDAALRQIVLNFV--LQGARSMTLQCLLHILKRMYSPESEDSF	2549
SCORPION	2474	GLADSDLTRLRVHNFV--SQNNHLPAAETFSRIKAVLQKMYSPeIEHMF [39]	2587
ALVINELLA	2456	GLSDDKIKNRVTLQNFV--SHSTRLPDSTVDRIVALLEMTYSPASEHOY	2537
CAPITELLA	2503	GLSDDDLNRLLTVQNFV--SHETRLPGETVERIVAMLEAMYPSTELHY	2570
SPONGE	2538	GLGDESNEVKLKMYYEYV--NQESNLSNTLDRITQLLVLYSKKTETQF	2612
OYSTER	2500	GLGDEDMQCRLLVQNFV--SSETRVPGNTLDRIVAMLEAMYSVPEKQF	2574
SNAIL	2500	GLCDDNLHCRLLTMQNFV--SSESRLPDGTVDRMISILEAMYPGSECNY	2574
TRICHOPLAX	2497	GLNDSSEENRLQLNFV--SNNRRLPSTGLTERLSSVLYALYSNAESeF	2571
SEA ANEMONE	2509	GLADDDNLRLKLVQNFV--SDETRLPNTTLERLVLVLRAMYSTNTEQOY	2583
PRIAPULA	2546	GLNDSDDSLRMVRFNFV--SHATRLPQTLLPRLLAIAQTLYSAPATEPHF	2620
ESHARK	2519	GLTDDMQLRLVQNFV--GHENRRLPTGTHDRIVAMLEAMYSNKIETQY	2593
STERLET	2532	GLTDENQGLQLVVRNFV--SHESRLPTSTLERMLVLRSLYSSKIEAHY	2606
COELACANTH	2520	GLTDENPGLQLVVRNFV--SDENRRLPVTGLDRMLVLLKAFYCNKIEQY	2594
HUMAN	2509	GLIDENPGLQLVVRNFV--SHETRLPNTLDRLLAL--NSLYSPKIEVHF	2582
CAECILIAN	2522	GLIDENAGQLVVRNFV--SDETRLPVVTTDRMLALLNSFYSPKIESHY	2596
PLATYPUS	2513	GLVDENMQCRLLVQNFV--SNETRLPNSILDRMLAL--NSFYSTKIEMHY	2586
CANARY	2511	GLIDENAEQLVVRNFV--SHETRLPNTLDRMLSLSSFYSTKIEIETHY	2585
OSTRICH	2481	GLTDENAEQLVVRNFV--SDETRLPANILDRMLALLNSFYSTKIEQY	2555
TURTLE	2520	GLMDENSGLQLVVRNFV--SDETRLPNTLDRMLALLNSLYSTKIEQY	2584
ALLIGATOR	2478	GLTDEISEQLVVRNFV--SDETRLPNTLDRMLALLNSFYSTKIEQY	2552
SOFTCORAL	2520	GLADENMQCRLLVQNFV--SDETRLPNSTLERLVLVLRAMYSPIESeY	2594
STONYCORAL	2547	GLADDDHRDLQLVVRNFV--SDEARLPSTGLTERLVEVLRALYSTTTEIY	2621
ACORN WORM	2545	GLSDEESYLRLVQNFV--SHETRLPVTGLDRMVSLECMYSPDAENQF	2619
LANCELET	2544	GLSDEESYLRLVQNFV--SHETRLPVTGLTERLVMLECMHSPTEPOY	2618
SEA URCHIN	2541	GLSDQDNYLRLVQNFV--SHETRLPKETLERLISMLGCMYSPGTENRY	2615
STARFISH	2555	GLSDEEASHRLVQNFV--SHETRLPVTGLTERLVMLECMYSPGTEHOY	2629
TERMITE	2535	KCQFEDF--RMLLSWRAQNAV--APMFADTLASQ----LIQTQ--SLSGTGEHT[5]--LRATQ--ASLAFQPTIE-----	2599
SHRIMP	2550	ECKFREEM--KVSTAWRARHASM--IPMFAETQASN--DTSLSNLLSYTQGSDTNME[4]AGVQATQ--ANVFSATQA-----PGA	2622
SCORPION	2588	TCAFQNY--AISSSWKRRAHATL--TPWFVDSLSSA-----ASFSDTSVKN[3]--QIRSTV--DVREFDPTQD----QA	2649
ALVINELLA	2531	DKCFKDF--HVRQSWQRHSTM--TPMFVDTQSTQ-----TSSDGSDDGGSTSP[1]--QLRATQ--DVQQFTATQG---VGT	2595
CAPITELLA	2578	ECKFQDF--AVSSTWYQRHAAM--TPMFLDTQSSQ-----SNDSPDAGLS[1]GQLRATQ--DAAQFTATQA---DG	2638
SPONGE	2613	ECRFEDYkEIDLQSWQRHLQ--TPLFAATQLSQ-----TQSDTGSIG[1]GMLRATVqQSLAFTPTQD-----	2672
OYSTER	2575	DKCFQDY--NVKSSWQRHAAM--TPLFANTMATQ-----SMMD--DDESYSGE-- --IRATQ--DAQQFTATLD---A--	2633
SNAIL	2575	ECKFRDY--SVQSSWQRHAAM--TPLFAVTQGSQ-----TMED--VEDSLRGG-- --VRATV--DVEQFTATME---TG-	2634
TRICHOPLAX	2572	ECKFHDY--NVNYSWQYRHAMM--TPLFAATQLGS--QGSMA--SFLSGSSSTDE HLLRATQsTNLQFTPTQD---TDA	2640
SEA ANEMONE	2584	ECKFBEEY--PIDYSWQRHVVM--TPLFAATQGS-----TQSHSQGGSLEP GALRATQ--LRVEFSPTMD---QSL	2645
PRIAPULA	2621	DKCFQDY--NIATSWQSRHAAL--TPLFTETQASQ-----ASSTQQTVA[5]GEIRATQ--VVPEFTATQD---VAG	2685
ESHARK	2594	ECKFQDY--NIDSSWQQRSTIL--TPMFVETQATQ--NSSRSQSEGLTAQGTIG GLVVRGTO--THYEFTPTQN---PDA	2663
STERLET	2607	DKCFQDY--IIDSNNWRHRSHTV--TPMFVETQVTV--GGTQYHTQDSP-- --QGTIG GQVRATQ--AQLEFTPTQA---AGR	2673
COELACANTH	2595	ECKFQDY--IIDSNNWRHRSHTV--TPMFVETQASQ--STARFRSQEGPEQVQGSILG GQVRATQ--VQFDFTPTQN---TGI	2664
HUMAN	2583	ECEFBQY--TIDSDWRFRSTV--TPMFVETQASQ--GTLQTRTQEGSLARWPVA GQIRATQ--QQHDFTLTQT---ADG	2652
CAECILIAN	2597	ECKFQDY--TIDSNWRYHSTV--TPMFVETQASL--SASRYRSQEGSFPAQSSLG GQVRATQ--QQYEFTPTQN---IGG	2666
PLATYPUS	2587	ECKFQDY--TIDSNWRFRTV--TPMFVETQASQ--SALRSRSQEGLLPQGQLL GQLRATQ--QYEFTPTQN---TDG	2655
CANARY	2586	ECKFQDF--VVDSSWRYRSTV--TPMFVETQASQ--STHRNLSQERSLSPSGSVR GQVRATQ--RQYEFTPTQH---GSG	2655
OSTRICH	2556	ECKFQDF--VIDSSWRYRSTV--TPLFVETQASQ--STHRNLSQERSLSPSGSGG GRVVRTQ--QQYEFTPTQN---ISG	2625
TURTLE	2595	ECRFQDF--TIDSNWRYRSTV--TPMFVETQATQ--SAKRNRSQEGSLSTQGSILG GQVRATQ--QQYEFTPTQN---VNG	2664
ALLIGATOR	2553	ECRFQDF--IIDSNNWRYRSTV--TPMFVETQASQ--SASRYRSQEGSLSTPGSQG AQRVATQ--QQYEFTPTQN---MSG	2622
SOFTCORAL	2595	ECKFQDY--EINFAWQQRNSTM--TPLFVSTLMP--GSSQS--SFGSHSMDIT--DG GQLRATQ--NPQFSMTQT---AGA	2661
STONYCORAL	2622	ECKFBEEY--QIDYSWQQRHLAIsTPMFVETQST-----QIGSDSQSFIETIG G--LRATQ--NLQFTPTQD---QRR	2687
ACORN WORM	2620	ECKFBEEY--QIDHSWKRRAHAAIsTPMFVETQST-----QIGSDSQSFIETIG NQVRATQ--DV--QFSATQE---VDG	2683
LANCELET	2619	ECRFQDY--QIDHSWKRRAHAAIsTPMFVETQST-----QIGSDSQSFIETIG GQLRATQ--DVLQFTATQA---SAA	2689
SEA URCHIN	2616	ACKFEGV--QIDHSWKRRAHAAIsTPKFVETQVQ-----SQSIRGSPSSQMSSTSSG[6]GQLRATQ--ATQNFATQD--naASS	2693
STARFISH	2630	ECRFQDY--TIDHSWQQRHLAIsTPMFVETQSSQ--ASSGSQSPPDSSLSR-- GEIRATQ--DAHQFIATQ1daVAS	2701

Supplementary Figure 3: DNA-PKcs COBALT Metazoa Vertebrate Invertebrate

TERMITE	2600	Q	-----S-GSSIGSLP-FSLS	-----SLLFTTGSFENQRKSY	KM	-GPGFGSSKLQ[3]EVS	2650	
SHRIMP	2623	T	--YNNVVT-DSTFTTLaDMEYE[2]	HaPTQGSSTGLFNVGASGGQDRRRF[1]RP	---	GIGNSRMR -PA	2683	
SCORPION	2650	S[1]	KAFNWLT-QTSIDTLG-DWGSS	-----STSSLLFTIGSDTKKINPID[4]NS	---	NQDTSKNKIE ---	2708	
ALVINELLA	2596	S[1]	GPYDWLT-QSSIDTFA-DSDVN	--MSTETSSLLFTIGATSSKSPASH[1]QR[4]	PGPRFQKHSLO[2]KAG		2664	
CAPITELLA	2639	S[2]	GPYNWLT-QSSDLTFS-DSONL	TlATQs-ESSLMFTVGSRIKSSKKT	-P	-GSEFGQKVR[3]---	2700	
SPONGE	2673	Q[1]	SSYNWMT--PSAQSV--DYSVP[2]	TvGATPTSDSSLLFTRPT---MRPPL[1]NP[2]	---	I SAERLG[4]SEG	2736	
OYSTER	2634	S[1]	JAFNWLT-GSSVDTFT-DY--S	TvGSET-SSSLLFTVGTQDMALRTGL[4]K-		PGPGFGRP---	RAG	2694
SNAIL	2635	S[1]	JAFNWLT-QSSDLTFA-DA--S	LmETNS-LSSLLFTVGSSSKGDASKT[4]RH[4]		TGNSFNCKQMAR[2]RTG	2705	
TRICHOPLAX	2641	R	---NWLD-PSSVDKSIqSYAAF[5]	SsTSETSSLLFLSSKSPRQRLQK	KP	LSKDFGQKLS[2]-TA	2707	
SEA ANEMONE	2646	S	QAFDWLN-PSS-QAD--SV--[3]	TvGSSSEAOSSLLFTGKPRASQRS--L	KP	VPHDFGSRRLA[2]-QS	2705	
PRIAPULA	2686	G[1]	STYNWLTqSSSIDTFA-DQSL	SvSSISSSSSSPYSSPADHHEPT[1]--	---	AKRRG[4]EPR	2747	
ESHARK	2664	R	NFNWLT-GNSLDTFA-EYSLP	SlASEPSSSSLLVFSRWSERLHRPAK	KP	VGPDFGKKRLA	LPG	2745
STERLET	2674	R	SSFNWLT-GSSIDTFS-EYSLP	S-SADSVSSSSLLVFGKRDKSQAAR	KP	VGSDFGKKRLG	LPG	2735
COELACANTH	2665	R	SSFNWLT-GSSVDTFA-EYSLP	S-SSESLSSLLAYGKRSEKSRAM	KP	VGPDFGKKRLA	LPG	2726
HUMAN	2653	R	SSFDWLT-GSSDPLV-DHTSP	S-S-----DSSLFAHKRERLQRAPL	KS	VGPDFGKKRLG	LPG	2709
CAECILIAN	2667	R	NSFNWLT-GNSIDTFA-EYVGP	S-SSESLSSLLFASKSEKSRRTSL	KP	LGNFVGKKRLG	LPG	2728
PLATYPUS	2656	R	NSFNWLT-GSSVDTFT-DYPGP	T-SSESL--STLLFTHKKSRTQKAGF	KP	LGPNFVGKKRVG	LPG	2716
CANARY	2656	R	SSFNWLT-GSSIDTFA-EYAVP	S-SSESLSSMLLVSKRSEKFKQATF	KP	VGPDFGKKRLG	LPG	2717
OSTRICH	2626	R	SSFNWLT-GNSIDTFA-EYMVP	S-SSESLSSMLLVSKRSEKFKQSAF	KP	VGPDFGKKRLG	LPG	2687
TURTLE	2665	R	SSFNWLT-GSSIDTFA-EYTVP	S-SSESLSSMLLVSKRSEKSRATL	KP	LGNFVGKKRLG	LPG	2726
ALLIGATOR	2623	R	KSFNWLT-GSSIDTFT-EYTVP	S-SSESLSSMLLVFNKRSEKSRQRTL	KP	VGPNFVGKKRLG	LPG	2684
SOFTCORAL	2662	T[4]	QYYDWLN-PSSLDTS--QSS--[4]	SvGSGQP--SSLLFKSNPNMRRFKT-L	RP	QSEQPSSTSA[3]DPS	2729	
STONYCORAL	2688	S	TAFDWLN-PTQ-ESNL-QPS--[3]	AmASTQTSQSLLFSTQSHKRRKM-L	KP	VPDGFQSKLS[2]-SS	2750	
ACORN WORM	2684	K[1]	JAYNWLT-GSQ-DTFS-EFS-S	StGTETSSLLFTIGTTKKAITR--	KP[1]	-SSGFGDKMG[1]-GK	2744	
LANCELET	2690	P[1]	JAYNWLT-QSSDLTFA-DYS-V	PlGTET-QSSLLFTTADSKKAKARR[1]KP[1]		-GPGFGSRLS[1]-GR	2752	
SEA URCHIN	2694	H[1]	JNGYNWLT-GSQ-DTFA-DYS-S	S--SSASESSLLFTMGSLPK--RTAQ[3]GV[1]	QDAGAGCS--	RDK	2752	
STARFISH	2702	R[1]	JAYNWLT-GSQ-DTFA-DYS-T	S--SASDQSSLLFTLGASKKMGRGQ[3]KT[1]	TDAGFGKEKLQ[4]RGR		2769	
TERMITE	2651	DEVDS	-----RSDRLAPNLHRRFLRrD-	DQKRIPHASREIQRSARQOELEQERGRLEANIASFREYRSGDFPDIEI			2721	
SHRIMP	2684	DEPDG	----NdADTMQSKLIRRRFVKnQdREKQSIYFAKIEBRKSLREKLEKERKFRREAVQV	MYRQYRVGELPDVQI			2759	
SCORPION	2709	-KLS	-----SNTFHLRRRFLK-D-REKSLRHFIRMERKQQLRQEREKQKQREGQV	TIYRQYIGDLPDIEI			2775	
ALVINELLA	2665	NRNDS	-----DDGLEILQLKRRFLK-D-SGQSTAYFARREARQRAIREEIAQEQRR	RENQVILYRKYRIGDLPDIEI			2735	
CAPITELLA	2701	-RVA	-----MGEANKEIMRLKRRFLK-D-QBSTARFPMKRNVRMKMREIQREQKMKREH	QVTVMYRQYRTGDFPDIEI			2772	
SPONGE	2737	GETPK	-----EKRRQVLQKRRALK-D-EMVTSFPMNREARMKMREELKQKRAARQS	YVVMYRKYRMGELPDIEI			2807	
OYSTER	2695	ASSK	PaERSRnEDQDSEMYLRRRFLR-D-EEQTKTYFIKRTRLEKMRREALREQKSRREH	QVTVMYRKYRIGDLPDIEI			2772	
SNAIL	2706	NSAG	PRNDNNTpDDEDN-VWKLRRRFLK-D-RSTASKYFARREIKKSKREERLQKQRL	LRRENQVTLYRKYRIGDLPDIEI			2782	
TRICHOPLAX	2708	SQPS	-QSVSQ--PSSSLNHLRRYIK-S-EMANNAYAKRERKQKQLEREEILKQKQI	ARENQVTLYRKYRIGDLPDIEI			2807	
SEA ANEMONE	2706	DSQA	-TPAMG-SQQQEILRLKRRFLK-DsQTKDRQYFIRMHEKQRMLQQTOSRLKA	ARESQVVMYRKYRAGDLPDIEI			2782	
PRIAPULA	2748	EESA	-----agGGDVMLRRRFLK-D-EQKTRVFAARREARRKORREAEATLSR	QREGQVVMYRKYRIGDLPDIEI			2819	
ESHARK	2726	DEVDS	-KTKGIvDQRADILRLRRRFLK-D-REKVSILFAKRGIREQRAEQKIKTEKMR	ERDAKVTLYSYRFGDLPDIEI			2802	
STERLET	2736	DEVDS	-RTKVK-DQRADILRLRRRFLK-D-QEKVSLIYAKKGVREQKAKENVAEQ	LKREAQVTLYSYRQDLPDIEI			2811	
COELACANTH	2727	DEVDS	-KIKGI-DQRADILRLRRRFLK-D-QEKVSLIYAKKGVREQKAKENVAEQ	LKREAQVTLYSYRQDLPDIEI			2802	
HUMAN	2710	DEVDN	-KVGGA-AGRDLRLRRRFLK-D-QEKVSLIYAKKGVREQKAKENVAEQ	LKREAQVTLYSYRQDLPDIEI			2805	
CAECILIAN	2729	DEVDS	-KARGI-DDRSDILRLRRRFLK-D-QEKVSLIYAKKGVREQKAKENVAEQ	LKREAQVTLYSYRQDLPDIEI			2784	
PLATYPUS	2717	DEVDS	-KTKGI-EERTEILRLRRRFLK-D-QEKVSLIYAKKGVREQKAKENVAEQ	LKREAQVTLYSYRQDLPDIEI			2792	
CANARY	2718	DEVDS	-KTKGI-EERABILRLRRRFLK-D-QEKVSLIYAKKGVREQKAKENVAEQ	LKREAQVTLYSYRQDLPDIEI			2793	
OSTRICH	2688	DEVDS	-KIKGI-DEABILRLRRRFLK-D-QEKVSLIYAKKGVREQKAKENVAEQ	LKREAQVTLYSYRQDLPDIEI			2763	
TURTLE	2727	DEVDS	-KARGI-DEABILRLRRRFLK-D-QEKVSLIYAKKGVREQKAKENVAEQ	LKREAQVTLYSYRQDLPDIEI			2802	
ALLIGATOR	2685	DEVDS	-TTKDI-NERABILRLRRRFLK-D-QEKVSLIYAKKGVREQKAKENVAEQ	LKREAQVTLYSYRQDLPDIEI			2760	
SOFTCORAL	2730	NENSS	-----QLQNIRLRRRFLK-D-RKETDVFYAKKIEARQKLRTE	SVQRQKVAARENQVTLYSYRQDLPDIEI			2799	
STONYCORAL	2751	SRSS	-HQSDpNEKKEILKLRFLK-D-QSQSFAFFAKQALKRNFREALQKRA	AREGAVVMYRKYRSGDLPDIEI			2827	
ACORN WORM	2745	QDQD	-STEDTSQDRDILRLRRRFLK-D-QEASRFAFFARREIRLKKMREEAQKQ	LRRHNMVTLYSYRQDLPDIEI			2820	
LANCELET	2753	QDQD	GAAEDSgQS--EIMRLKRRFLK-D-QDVTKAYHARRQIRMOKMREEV	KQRAKRGNLVTLYSYRQDLPDIEI			2828	
SEA URCHIN	2753	EARKA	-----PSeEG-KEVQLKRRFLK-D-QSSQSAFFAKRATRQKELRE	EVQKSORREAVQVTVMYRQYRTGDPDIEI			2828	
STARFISH	2770	DEVDA	----KQsGEDKKINRLRRRFLK-D-HSSQAYFARREMKRQKLEKILE	EQREKFSVTVMYRKYRIGDLPDIEI			2843	
TERMITE	2722	SYS	AIKPMQELAKRDAVARHLFVLLFDGLGELYD----	EKEYTQKVQKMGSIVSTTKDYTTVMYGAVMEIALCH			2796	
SHRIMP	2760	PHRAL	IGLQALSQRDEKVARLLFVLAQGVINSAGTAMHHR	EEQWQELHEALNGILSSYMCCPQMLR	TVLHLMIN		2839	
SCORPION	2776	NYS	SIIVPLQALAHDDIEICRMLFQSLILSVCCYKSNQV-	TEYSEFCRSLSSALNEILKKS	VHYHPQLVAFCEYCLNCD		2854	
ALVINELLA	2766	EYFN	IAPLQALQKSRMAMLLSLTFAIHAELVTVCA--	DNRSIHARISNSLNTMLSTTNQY	YAPFINCILHMAYS		2813	
CAPITELLA	2773	KYS	FLIAPLQALQKSDTIKLLFVAVFQAIPTQIESEKTERE	SQSLVAKIESSLNKILETSTQY	SPFPGVLEIAYLF		2852	
SPONGE	2808	KHSE	LIRPLQALAQKSDSLARLLFCSLFNSIFSQDLHTE	DAATKGVIEGNINTILDCSTQY	YPPFISGLDICYE		2887	
OYSTER	2773	KYS	IAPLQAVAHDRSSVAKLLFCAIFKGFIPKMDVEK	TEREVQETIQIQKSGVVLTSIQY	TPFISCLLDVLYSL		2852	
SNAIL	2783	KYS	IAPLQALAHDRNTIAKLLFCAIFKGFIPKMDVEK	TEREVQETIQIQKSGVVLTSIQY	TPFISCLLDVLYSL		2852	
TRICHOPLAX	2783	KHSE	LIRPLQALQKSDSLARLLFCSLFNSIFSQDLHTE	DAATKGVIEGNINTILDCSTQY	YPPFISGLDICYE		2887	
SEA ANEMONE	2783	KHSE	LIRPLQALQKSDSLARLLFCSLFNSIFSQDLHTE	DAATKGVIEGNINTILDCSTQY	YPPFISGLDICYE		2887	
PRIAPULA	2820	QFCH	LIRPLQALQKSDSLARLLFCSLFNSIFSQDLHTE	DAATKGVIEGNINTILDCSTQY	YPPFISGLDICYE		2899	
ESHARK	2803	KYS	LIRPLQALQKSDSLARLLFCSLFNSIFSQDLHTE	DAATKGVIEGNINTILDCSTQY	YPPFISGLDICYE		2881	
STERLET	2812	QHS	LIRPLQALQKSDSLARLLFCSLFNSIFSQDLHTE	DAATKGVIEGNINTILDCSTQY	YPPFISGLDICYE		2891	
COELACANTH	2803	HYS	LIRPLQALQKSDSLARLLFCSLFNSIFSQDLHTE	DAATKGVIEGNINTILDCSTQY	YPPFISGLDICYE		2882	
HUMAN	2786	KHS	LIRPLQALQKSDSLARLLFCSLFNSIFSQDLHTE	DAATKGVIEGNINTILDCSTQY	YPPFISGLDICYE		2865	
CAECILIAN	2805	AYS	LIRPLQALQKSDSLARLLFCSLFNSIFSQDLHTE	DAATKGVIEGNINTILDCSTQY	YPPFISGLDICYE		2884	
PLATYPUS	2793	EHS	LIRPLQALQKSDSLARLLFCSLFNSIFSQDLHTE	DAATKGVIEGNINTILDCSTQY	YPPFISGLDICYE		2872	
CANARY	2794	EYS	LIRPLQALQKSDSLARLLFCSLFNSIFSQDLHTE	DAATKGVIEGNINTILDCSTQY	YPPFISGLDICYE		2873	
OSTRICH	2764	EYS	LIRPLQALQKSDSLARLLFCSLFNSIFSQDLHTE	DAATKGVIEGNINTILDCSTQY	YPPFISGLDICYE		2843	
TURTLE	2803	EYS	LIRPLQALQKSDSLARLLFCSLFNSIFSQDLHTE	DAATKGVIEGNINTILDCSTQY	YPPFISGLDICYE		2882	
ALLIGATOR	2761	EYS	LIRPLQALQKSDSLARLLFCSLFNSIFSQDLHTE	DAATKGVIEGNINTILDCSTQY	YPPFISGLDICYE		2840	
SOFTCORAL	2800	KHS	LIRPLQALQKSDSLARLLFCSLFNSIFSQDLHTE	DAATKGVIEGNINTILDCSTQY	YPPFISGLDICYE		2879	
STONYCORAL	2828	KYSE	LIRPLQALQKSDSLARLLFCSLFNSIFSQDLHTE	DAATKGVIEGNINTILDCSTQY	YPPFISGLDICYE		2907	
ACORN WORM	2821	KHM	LIRPLQALQKSDSLARLLFCSLFNSIFSQDLHTE	DAATKGVIEGNINTILDCSTQY	YPPFISGLDICYE		2900	
LANCELET	2829	KYS	LIRPLQALQKSDSLARLLFCSLFNSIFSQDLHTE	DAATKGVIEGNINTILDCSTQY	YPPFISGLDICYE		2908	
SEA URCHIN	2826	KHS	LIRPLQALQKSDSLARLLFCSLFNSIFSQDLHTE	DAATKGVIEGNINTILDCSTQY	YPPFISGLDICYE		2905	
STARFISH	2844	KYSD	LIRPLQALQKSDSLARLLFCSLFNSIFSQDLHTE	DAATKGVIEGNINTILDCSTQY	YPPFISGLDICYE		2923	

Supplementary Figure 3: DNA-PKcs COBALT Metazoa Vertebrate Invertebrate

TERMITE	2797	SRYSITLQAEDITTVSRFSGLLALGCLSLLEEILIQKdTVSEAGSSKRKST---FEPSTeEILWLSLADLYKHMDEWVVVRG	2873
SHRIMP	2840	D--VRNPESLTAACLGSRLEALGILVLERQALLSKRGEPPHARKMRKDAEALSQdDSLWLSIAEMYKLNMMWVVVRG	2917
SCORPION	2855	VKEMDDYDQICTASQASHKQSLGILLLEDDHLICynFKSSNPAAKRIKLNKFLISD-eLSIWLKMAEIKYKSLSDYDVSVHG	2933
ALVINELLA	2814	IHNLTLEPNSISSACLGLQOPMGIMLLEKMLIHAeNPtCQPSKHHRTIGPQVSRD--INVWLELAKLYKSLGIDYDVLKG	2891
CAPITELLA	2853	PKQLKQPQGVSTVNCMSDQOPLGILLLEEGLLHS-PEDQSPAKSRSRDRSSRTQdTEPWELELAKLYKSLSDYDVLHG	2931
SPONGE	2888	NS-LKIKPPSITTSLSASKQEFTEGIMLLEKQLLNL--VDSKSAKRRTNKSNEVTE---TWIELARLYKSLSDYDVLHG	2961
OYSTER	2853	RSKLKVDVSDVSSAAMPNGIPLGICVLEEQLISQdED--ERPSKRGRSDNAV-VSTdTLWIELARLYKSLVKEVDVLLG	2929
SNAIL	2863	RSSLKVEVSELSIAAKISNLQPLGIEVEERLITEdSGG-ARPSKRSRVDVTP-VTKdMQWIELAKLYKSLGDFDVLHG	2940
TRICHOPLAX	2860	KELS-TQSSFASVASLASSQOPGILLLEKQIMHL--DTEEPPSKRIKTSASEATS-N--WIELSKLYKSLGIDYDVLHG	2933
SEA ANEMONE	2863	SMLK-VQPSVSTASLASSQOPMGILLLEKQLLSQ-EAEPK-SHKRMRTEHSPSDT-TAAWLELAKLYKSLVEEFDVLHG	2938
PRIAPULA	2900	ISILRLDPAVTVTSQTSMQQNLGIVLLEKMLMQCaDDESRPAKMRAGSGMGVShTDTWIELARLYKSLGIDYDVLHG	2979
ESHARK	2882	KDLLGLDSTSVRSTSLASSQOPMGILLLEKSLIHS-TTNEEPPTKARGRQELPPDtdVARWIELATLYRSLGIDYDVLHG	2960
STERLET	2892	KELLNTEPSSVSSCLASSQOPMGILLMEESLIKG-LVPEEPPAKRARGRLELPPD--TARWIHLAKLYRSLGIDYDVLHG	2968
COELACANTH	2883	AELLMLDASVSTASLASSQOPMGILLLEKQLISQ-EAEPK-SHKRMRTEHSPSDT-TIRWLELAKLYRSLGIDYDVLHG	2959
HUMAN	2866	AALLSLDPAVTSAGCLASSQOPMGILLLEKQLLSQ-LPAELP-AKRVRGARLPPD--VLRWLELAKLYRSLGIDYDVLHG	2941
CAECILIAN	2885	TELLNLDPNSVSTASLASSQOPMGILLLEKSLIHS-LVPEEPPAKRARGRLELPPD--VVRWLELAKLYRSLGIDYDVLHG	2961
PLATYBUS	2873	TELLNLDPNSVSTASLASSQOPMGILLLEKQLISQ-EAEPK-SHKRMRTEHSPSDT-VVRWLELAKLYRSLGIDYDVLHG	2949
CANARY	2874	RELELDSANVSTASLASSQOPMGILLLEKQLISQ-EAEPK-SHKRMRTEHSPSDT-VIRWLELAKLYRSLGIDYDVLHG	2950
OSTRICH	2844	RELELDSANVSTASLASSQOPMGILLLEKQLISQ-EAEPK-SHKRMRTEHSPSDT-VIRWLELAKLYRSLGIDYDVLHG	2920
TURTLE	2883	RELELDSANVSTASLASSQOPMGILLLEKQLISQ-EAEPK-SHKRMRTEHSPSDT-VIRWLELAKLYRSLGIDYDVLHG	2959
ALLIGATOR	2841	KELLIDDSVSTASLASSQOPMGILLLEKQLISQ-EAEPK-SHKRMRTEHSPSDT-VIRWLELAKLYRSLGIDYDVLHG	2917
SOFTCORAL	2880	GKLS-LEAGKVTTASIGSLQOPTGIMLLEKQLISQ-EAEPK-SHKRMRTEHSPSDT-TATWIELSKLYKSLVEDFDVLHG	2957
STONYCORAL	2908	CKLRSVDSASVSTASLASSQOPMGILLLEKQLISQ-EAEPK-SHKRMRTEHSPSDT-TTCWIELSKLYKSLVEDFDVLHG	2985
ACORN WORM	2901	AELLMLDASVSTASLASSQOPMGILLLEKQLISQ-EAEPK-SHKRMRTEHSPSDT-ISTWIELSKLYKSLVEDFDVLHG	2978
LANCELET	2909	PRKLSVDSASVSTASLASSQOPMGILLLEKQLISQ-EAEPK-SHKRMRTEHSPSDT-ISTWIELSKLYKSLVEDFDVLHG	2986
SEA URCHIN	2906	SEQLTLDPAVTSAGCLASSQOPMGILLLEKQLISQ-EAEPK-SHKRMRTEHSPSDT-ISTWIELSKLYKSLVEDFDVLHG	2983
STARFISH	2924	SEQLTLDPAVTSAGCLASSQOPMGILLLEKQLISQ-EAEPK-SHKRMRTEHSPSDT-ISTWIELSKLYKSLVEDFDVLHG	3001
TERMITE	2874	IFHKYLNLC-GENVHKALKWETS GHWDKARMEYEAALSSMDQDGL-----SDYVEALYKCLAHLSDWKGLNNQVRRQ	2945
SHRIMP	2918	VVQKLGAIKEBTQKALEAEATNNHVKAFLLYRQSLDTDWEEEP---LAAENRLEWEYNSCAAILGQWSELENFVEKR	2994
SCORPION	2934	IFNSNLNI-QEETKQALEFESRGEYLLAVKIYKSLYDQTEWSAE-P-NQAEIDLWDNAILQCYDYLTQWDLQLSINR	3010
ALVINELLA	2892	IFGSKLGT-KEITLAEAEASGSDYQAVQLYKALVCTDWEDEP---DELEKDFWADSLHCYEHLTQWKLLECTLTN	2967
CAPITELLA	2932	IFSSQIGS-KPATRLAEAEARGDYRSALQYNEAMSQDDEhP-TEAEINMWDSSRIECAENLTQWRDVELTSTSD	3009
SPONGE	2962	IFNLDLDT-KDVTKALEAEERGDYLTALNLYKKAIDF-DWQGES-P-QVEEEDLWEDSLNAYSHLTQWKLKASTCN	3038
OYSTER	2930	IFSGRIGT-KDITKAEVQMEARGDYKAVKLYNQALSCNDWEN-P-PTIEVDMWDESRMECLDNLISQWKELEGVAMS	3005
SNAIL	2941	IFSGMLKT-KEVTQLALIEESHSEYKAAIALYNKALAESADHDP--P-LEAEIDLWDESRMECLNRLTEWTKLEMTTDA	3016
TRICHOPLAX	2934	IFSGHLGT-KDITQALAEASRHDYAAAVKYINQAMDCSSWDPGE-P-QAEEDLWESIRLECLYNLTQWDLKLEYLSLVN	3010
SEA ANEMONE	2939	IFSDHIGT-KPITRLAEAEARGDYAAQALKYNEAMSQDDE-WSSK-P-QQEEEDLWDDARMQCFANLAKWGLDEYKSTG	3014
PRIAPULA	2980	IFNDKIGT-QTCTQALQAEASCDYKLARKLYQALAE-EGWESegP-QGGERDLWDISLMQCLDRDWTALDAHTKEC	3056
ESHARK	2961	IFSGRIGT-KDITKAEVQMEARGDYKAVKLYNQALSCNDWEN-P-METEKFDFWEIAALECYNHLETEWKALEYCVSTN	3037
STERLET	2969	IFSGKIGA-KSITSMALQAEAKSDYAEAVKLYNEALNTEEWTDPGE-P-AEAEKDLWEIAALESYHLETEWKSLEYCVSTN	3045
COELACANTH	2960	IFSGMIGT-KQVTKALLAEAKSDYSEAVRLYDEALNVEEWPDPGE-P-TEAEKDFWELAELECYSHLETEWKSLEYCVSTN	3036
HUMAN	2942	IFSDHIGT-KPITRLAEAEARGDYAAQALKYNEAMSQDDE-WSSK-P-QQEEEDLWDDARMQCFANLAKWGLDEYKSTG	3018
CAECILIAN	2962	IFSGKIGT-KPHTKALLAEAKSDYATAAKLYDEALNPDWSDNDE-P-TEAEKDFWELAELECYSHLETEWKSLEYCVSTN	3038
PLATYBUS	2950	IFSGRIGT-KDITKAEVQMEARGDYKAVKLYNQALSCNDWEN-P-PTIEVDMWDESRMECLDNLISQWKELEGVAMS	3026
CANARY	2951	IFSGKIGT-KEITQKALLAEARNDYAEAAQYDKALSQEDWQDGE-P-TEAEKDFWELAELECYDHLTMWKSLEYCATVN	3027
OSTRICH	2921	IFSGKIGT-KEITQKALLAEARNDYATAAKHYDEALSKEDEWQDGE-P-TEAEKDFWELAELECYDHLTMWKSLEYCATVN	2997
TURTLE	2960	IFSGRIGT-KDITKAEVQMEARGDYKAVKLYNQALSCNDWEN-P-PTIEVDMWDESRMECLDNLISQWKELEGVAMS	3036
ALLIGATOR	2918	IFSGRIGT-KEITQKALLAEAKSDYVEAVKYQDEALSQDWSDPGE-P-SEAEKDFWELAELECYDHLTMWKSLEYCATVN	2994
SOFTCORAL	2958	IFNSHIGT-QSITKDAEAEARGDYTEALKLYNQALSCNDWEN-P-PTIEVDMWDESRMECLDNLISQWKELEGVAMS	3035
STONYCORAL	2986	IFTHGIGT-KDITREAMEAEARGDYQAALKLYNEAIGTDDVVIKE-ELRQEEEDLWDSVRLQCLADLTQWKELEKCSVES	3063
ACORN WORM	2979	IFSGKIGT-QVYTRAEAEASANYQKAAANLYDEALNVEEWPDPGE-P-EQVEEDLWDDCLRCYQELTDQWKLQASTIN	3055
LANCELET	2987	IFSRKIGT-QVYTRAEAEARGDYKAVKLYNQALSCNDWEN-P-PTIEVDMWDESRMECLDNLISQWKELEGVAMS	3063
SEA URCHIN	2984	IFGALIKT-KDVTQEAQAEARGDYSALELYSKAISSDWGPDP--V-AREEEDFWEARLQCCNQLTKWDMESFSTDO	3059
STARFISH	3002	VFSACIGT-HEITKTALEAEARGDYSTALKLYNQAFEM-DWDEGA-V-SQVEEDLWDESRNLCCNQLTKWKLQNYSTVN	3077
TERMITE	2946	V--ENN----LDQLWTDEWLQEKLLPQILLSEIQMMLDKGVDskREQFLQVDRWRDRDKSDYLSH-YCEELAAIFL	3017
SHRIMP	2995	FlgDDD-GEVDLNRVWLLPKPTATALPALVHVSKLMLNILD-GSET-DGNLIAFIDQSMGDHRRMSLEGD-LPLQLGLVLA	3070
SCORPION	3011	L--DENqKQPNLNKIWEPPYQENYLPFLIKSKLKLIE-NRN--DQSLLCFIDSALKEENKKKYLEEN-FSEELALLYI	3084
ALVINELLA	2968	L--DDV-RSANDLRIWEDTYQDTPYLYIHSKLLKLLnGEG--QDDLATFIDNAMKVTERRALLESQ-YVSELALLYI	3041
CAPITELLA	3010	L--EGS----SLAVWDSYHQEVYLPMLRSKLLILN-GDTs-QDNLLSFIIESLTPVHKAFTEGS-FSSELALVCI	3080
SPONGE	3039	IgeETN---SKLEQLWKDSYQEHYLPFVLSKLLKWC-TDSS--DHGLASFLDKSLSEANRSVLESH-YPQELTLYS	3111
OYSTER	3006	I--SSN---SISQVWKDTYQEHYLPYIIRSKVKLLMLQ-GDGD-QQPLLTFFIDCMQTEQKALIESR-YSEELALLYI	3076
SNAIL	3017	L--SQE-GEISLASVWDDTYMYETYPYLIIRSKLKLILLH-GDEK-QQSLLSFIDSMKNPQRAHLESR-YCEDLALMYV	3090
TRICHOPLAX	3011	V--DNN-DPPSFDKIWDNYQENYLPFLFKSKAKVMCE-NLagSDDFIQVNLKSLANDEHLSVLENRhdC-CLALIHV	3085
SEA ANEMONE	3015	V--DDEgNPPDLKTIWDTYQEHYLPFIMRSSIKLICE-GE--eRPCFLEFLRSMNNEKAFLESR-YGDDLALLFI	3088
PRIAPULA	3057	LipEGS-SEADQLLWEDTYEENHLPFVPMARLKRLLV-EGAr-DQTLFSVDAATGHDPDRAVIETW-HGEELALLYI	3132
ESHARK	3038	I--DDK-TPADENIWNDFYQETYPYLYMIRSKVLLQL-GEV--DQSLLTfVDRAKMKVQRKALIESR-YSEELALLYI	3110
STERLET	3046	I--DDS-SPADLEKIWDPPYQAYLYPYMRSVSKLLQL-GEV--DQSLLTfVDNAMKVEERKSIETS-YSQELSLLYI	3118
COELACANTH	3037	I--DDK-TPADENIWNDFYQETYPYLYMIRSKVLLQL-GEV--DQSLLTfVDNAMKVEERKSIETS-YSQELSLLYI	3109
HUMAN	3019	I--DSE-NPPDLNKIWSPPYQETYPYLYMIRSKVLLQL-GEV--DQSLLTfVDNAMKVEERKSIETS-YSQELSLLYI	3091
CAECILIAN	3039	I--DSE-NPPDLNKIWSPPYQETYPYLYMIRSKVLLQL-GEV--DQSLLTfVDNAMKVEERKSIETS-YSQELSLLYI	3111
PLATYBUS	3027	I--DSE-NPPDLNKIWSPPYQETYPYLYMIRSKVLLQL-GEV--DQSLLTfVDNAMKVEERKSIETS-YSQELSLLYI	3099
CANARY	3028	I--DSG-KPPDLKTIWDPFYQETYPYLYMIRSKVLLQL-GEV--DQSLLTfVDNAMKVEERKSIETS-YSQELSLLYI	3100
OSTRICH	2998	I--DSG-QPPDLNKIWSPPYQETYPYLYMIRSKVLLQL-GEV--DQSLLTfVDNAMKVEERKSIETS-YSQELSLLYI	3070
TURTLE	3037	I--DSE-NPPDLNKIWSPPYQETYPYLYMIRSKVLLQL-GEV--DQSLLTfVDNAMKVEERKSIETS-YSQELSLLYI	3109
ALLIGATOR	2995	I--DSE-NPPDLNKIWSPPYQETYPYLYMIRSKVLLQL-GEV--DQSLLTfVDNAMKVEERKSIETS-YSQELSLLYI	3067
SOFTCORAL	3036	F--DEANGLNQLWDDYQEHYLPFLLSKLLKFLI-GD--rDEVFNFIKDSLKNKRVYLENK-YSDILALLFI	3109
STONYCORAL	3064	I--DDK-NPPDLKTIWDPFYQEHYLPFLLSKLLKFLI-GD--gDMTINEFVAKAMKTSERAAALRSR-YSDSLALMYV	3136
ACORN WORM	3056	I--DDN-DPPDLKTIWDDYQEHYLPYVYKSKLKLME-DDDtdDQSLLTfIDKSMQHKERKALIENR-YSEALAMLYL	3130
LANCELET	3064	I--DED-SPPDLKTIWDDYQEHYLPYVYKSKLKLME-DDDtdDQSLLTfIDKSMQHKERKALIENR-YSEALAMLYL	3136
SEA URCHIN	3060	I--EGK-GSNDLSQIWNDDYQEIYLYPYMRSKLRKLE-GEV--DQSLLTfIDKSMQHKERKALIENR-YSEALAMLYL	3132
STARFISH	3078	I--DDN-SPHDLKTIWDDYQEHYLPYVYKSKLKLME-DDDtdDQSLLTfIDKSMQHKERKALIENR-YSEALAMLYL	3150

Supplementary Figure 3: DNA-PKcs COBALT Metazoa Vertebrate Invertebrate

TERMITE	3018	IQDKLDQAQHQVEHSLTMFLDWSAALN--PSSHNLRTRKQLLDLQKTAELKACLAFAATNGEHSKQ---ELLAKELVKRWNK	3092		
SHRIMP	3071	HQEKFEQANVYANTATSMFLTLTSLQYS--VLTNPPLDQLQNVQLLTELSDCLNNVYADRDFY---SSKVKQTVTSWKK	3145		
SCORPION	3085	IQENYDRAQYYSQCLQDFLKEWSSLN--VLMPDIRKTKLQSLQKHIELEQELNFDITRYRIDE---YHFKNLTRDWLK	3158		
ALVINELLA	3042	WQEEYDRAMSHVDQAIQLFLQNWAGLD--ALMSNRLHLRLTQKLTMEHEFLQFMKNKHSISF--MQSVIQANAWMR	3116		
CAPITELLA	3081	HQELYDKAKHYANMSLQAFIQDWNALS--TRTSTRATKQLKLEFFTEMQEFLSVIKTTSGEDFPr---QIDRTLHKWEA	3155		
SPONGE	3112	LRDDYDRARYYSLSLKAKQQIWSVQDgiSSSTGAVSSVQSLQRLTEMNEFITFMKSNDFSSPg---PVNNLLRKRK	3188		
OYSTER	3077	WQADYDRARYHSTLATQFFLLDWSST--SLSVSRKSLQRLQPLVELQEFLSFMASEGNFTS---VTPANSLIERWQA	3151		
SNAIL	3091	WQKNFDLARHYARLAVQSPFDQWSSD--SLMTASRTHCLQRLQLLELQEFLLDFVADKNFTS---FEPHQIARWQ	3165		
TRICHOPLAX	3086	LLEKYDRARYYLDPSIQFLQDWSALD--SLLYSRASKLQSLQTLTEMQEFLLQFMDGGRNFES---VTPVLSLISKWST	3160		
SEA ANEMONE	3089	LRDDYGRARYHVNTCFQAFKLDWSSGLS--SMVSSRSASKLQSIQKITEMQEFLEFVVKEGKLLK--KT--LEDLFSRWSV	3162		
PRIAPULA	3133	VQGDYTRARHHAARCLQAFRLDWSALD--ALMLASRARLRSLOKLTTEMNEFLDAITATPDAFT--rNDTARALVDRWMD	3208		
ESHARK	3111	LQDDVDRAKYIINNCFEVMQNYSSID--TLLHQSRLLTKLQSLQAVTEMQDFLHFISKEYNFIS---EVPRLKLLRRTWTF	3185		
STERLET	3119	LQGDVDRAKYIYVNNCQVFMQNYSSID--TLLPGSRLLTKLQSVQALTEIQDFLNFMTKDV---S---QTSLKSLIRIWTDF	3190		
COELACANTH	3110	LQDDVDRAKYIYVNNCQVFMQNYSSID--TLLHQSRLLTKLQSVQALTEIQDFLGFISKPDHLNS---RASLRLRLNWS	3184		
HUMAN	3092	LQDDVDRAKYIQNGIQSFMQNYSSID--VLLHQSRLLTKLQSVQALTEIQEFLSFIISKQGNLSS---QVPLKRLNLTWTF	3166		
CAECILIAN	3112	LQDDVDRAKYIYDNGIQVFMQSHSSID--TLLNKSRLTKLQSVQALTEIKDFIHFISKPSNLTS---QTSLKRLRIWSS	3186		
PLATYPUS	3100	LQDDVDRAKYIIDYCIQFMQNSID--ALLQSRLLTKLQSVQALTEIQDFNFISRPSNLSS---QASLKRLLRIWTF	3174		
CANARY	3101	LQDDVDRAKYIYISNGIQFMQSYSSID--SLLYQSRITKLQSVQALTEIQDFNFMTKRSNLAS---EASLKRLLRTWTF	3175		
OSTRICH	3071	LQDDVDRARYYISNGIQFMQSYSSID--TLLMGTIRSSKLQSVQALTEIQDFIHFMTKTSNLAS---QASLKRLLRIWTF	3145		
TURTLE	3110	LQDDVDRARYYISNGIQFMQNYSSID--TLLHQSRLLTKLQSVQALTEIQEFLNFISKPSNLAS---QVSLKRLRIWTF	3184		
ALLIGATOR	3068	LQDDVDRARYYISNGIQFMQNYSSID--ALLHQSRLLTKLQSVQALTEIQDFINFMRPSNLAS---QASLKRLLRIWTF	3142		
SOFTCORAL	3110	LQDDYDRARYYISLCLQAFLEDWSSGLD--SISMTSSRAHLSLQALTEMQEFLLDFISHEDNFST---ISSVKSLKRWSS	3184		
STONYCORAL	3137	LQDNCDSASYAALSQSPFLSDWAGLD--SNLRSRSIKLQSLQKITEMQEFLEFAEENFSS---PMPVLSLKNWYS	3211		
ACORN WORM	3131	LQDDVDRARYYISNGIQSFLQDWSGTD--TLLMGTIRSSKLQSVQALTEMQEFLLFTITNERNFDE---HKPVSDLISKWTF	3205		
LANCELET	3137	YQDDYGRARYYVGNCTDAFLQDWSGMD--RLMTSSRAAKLQSLQKLTTEMQEFLELISNDRNFET---PWPVTRLEKWS	3211		
SEA URCHIN	3133	LKEDYDRAMPYLANCTSSFLQDWSGLG--PLMITSRRALKQCIQRLTEKQNFLLKAIKPDLQEA1gcQKSLLE--LLDRWSG	3207		
STARFISH	3151	IQEDYDRAMPYLANCTSSFLQDWSGLG--PLMITSRRALKQCIQRLTEKQNFLLKAIKPDLQEA1gcQKSLLE--LLDRWSG	3227		
TERMITE	3093	NVPSA--FDSLLRWDIRAMYRKKF--TNRIDQMLEN	-----TGASNALSRTE	-----LAMVD	3140
SHRIMP	3146	QKCRIDDDNPL--MTQCLASYRDLY--LHLMKELKPE	-----DSDL	--VSNLIKDKTNFTHRFVIR	3199
SCORPION	3159	RYPDI--FDSVINWDDIIMNRSLY--MEKIVSKLQK [3]	QSTFSFLEESMDTSIVDSEP [3]	FDSEKFLKEQRLKMKLKFVE	3236
ALVINELLA	3117	RSPDPVDPDTIWDVMSYRILY--LDQMAQHLKN	-----	[5]EGMDIFNEHKVNFRLKQAE	3174
CAPITELLA	3156	RSPDLRLDSVIVDNIILNRRVY--MDHFAEHLTS	-----IDAKIM	-----PFGKQVVMSSLAQVD	3209
SPONGE	3189	RFPDPKLDVPIWDDIITTRWMM--LRKISTKLQD [4]	QCEYLLDDDGSSCSVDSDM	-----KNENINMFMRAAD	3258
OYSTER	3152	RALHPLDTEAVDNNVTRNMVF--LDHISNRLST	-----SLVKKEEDAMEEDEE	---D--LFLASKIHLRLKMD	3215
SNAIL	3166	RYPHVQLDLVDIWDVVTNRNVY--MDKIRDQMLS	-----S-----NLMEEDHD	-----SSIFEDIKRLQQLKLAH	3224
TRICHOPLAX	3161	RFPNVEIDPINWDDIIVNRCMY--LRKILLQYRV [5]	TSTEDSMEIDGEDRVYITF--	PALKKRIAEVEVSLYKLLAD	3237
SEA ANEMONE	3163	RFPNSKLPISVWDDVITNRRIFgLTVCVYRP--	---DSMDVDGEWSCPSV--	DALRERITREVALQLKMWQ	3228
PRIAPULA	3209	HMPHTLDPVISWDDVTINRCLY--MDLHSRHF--	-----HGNQFAGSDP	-----FLEQKFNFLFAYQ	3263
ESHARK	3186	RYPDAKMPMSIWDVITNRCFF--LDKIQERLVS	VQADESMEVDREGEVETRM [5]	EDINMAIRSCFNMKLMKMAE	3263
STERLET	3191	RYPDAKMPMNWDDIITNRCFF--LDKIAGKLTN	SEADNSMEVDGGEDTGVKME [4]	EDVGSIMIRGCKFSMKLMMAD	3267
COELACANTH	3185	RYPDAKMPMNWDDIITNRCFF--LDKIQEHLCK	VPADESMEVDGEGDASPRMD [4]	PNISAMVQSCFNMKLMKMAE	3261
HUMAN	3167	RYPDAKMPMNWDDIITNRCFF--LSKIEEKLTP	LPEDNSMNVDDQGDPSDRME [5]	EDISSLIRSCFNMKMKMID	3244
CAECILIAN	3187	RYPDAKMPMNWDDIITNRCFF--LDKIREKLPH	QPADSMEVDGGGDASDRME [5]	EDITSMIRSCFNMKLMKME	3264
PLATYPUS	3175	RYPDAKMPMNWDDIITNRCFF--LSKIQEKLQ	LQADDSMEVDGGGDTDRME [5]	DDIYSMIESCKFSMKMKMIE	3252
CANARY	3176	RYPDAKMPMNWDDIITNRCFF--LDKIQEKLPS	QDANDSMEVDGEYSAGDQME [5]	ENIHSMIRSCFNMKMKMIE	3253
OSTRICH	3146	RYPDAKMPMNWDDIITNRCFF--LDKIQEKLPR	DQANDSMEVDKEDIDGDQME [5]	EDISSMIRSCFNMKMKMIE	3223
TURTLE	3185	RYPDAKMPMNWDDIITNRCFF--LGKIQEKLPN	IQADDSMEVDGRGDVGDQME [5]	EDIHSMIRSCFNMKMKMIE	3262
ALLIGATOR	3143	RYPDAKMPMNWDDIITNRCFF--LDKIQEKLNL	VQADDSMEVVEAGDIGDEME [5]	DNHSMIRSCFNMKMKMIE	3220
SOFTCORAL	3185	REPDPKLSHVGWEDVMTNRSVF--LDKILLKFGQ [4]	HSSDSMEID--GLNT--	TQLEEIFLRERVLFSLRLSE	3255
STONYCORAL	3212	RIPPHILHPIGWDDIIVTRNVLF--MSKFLQKF--	---EAMGAE--ERSGICL--	DDIKDKFPKQVEVLKLCMAN	3275
ACORN WORM	3206	RIPDPKNDPNTWDDIIVTRNVYF--LRKLFQKSGD	-----AMEGGDQAMVNAI--	-----SKDKLMLKLVLD	3265
LANCELET	3212	RYPDKNDPISVWDDIIVANRCLY--L-----D	-----KLNDFEQMAARGVL [6]	EPFSHRAQREQFLRLVLVLD	3277
SEA URCHIN	3208	NLPDKNDPISVWDDVTVQYRCLY--MDKLCNLLGD	-----SGGGGGGDSMETED	QKFDLVRREKVLKLSMKMAD	3275
STARFISH	3228	CHLDSKDPINWDDVVSNNRLY--MDKLGSRFIR	-----SES-----QAGGEE	TALEKRILRERLWLEKMD	3290
TERMITE	3141	SALYQENFYIARKYLREaREKMSNSGTDE--LQCSLAYSKAKWLQALKNTT--dEKLKLGLDSWSVIEDQr--FEQY			3213
SHRIMP	3200	AALHNSYHLANRHLK--ISLSEDEYS--KAQFYFLMAETHLIRGQKQTD---RLKYLVEAWAKYLGRV--SSMSI			3269
SCORPION	3237	AALLOGNLQVAVKHLK--SQQIAKELKADH--HWINCILHYCKIDLKAKKNQYNP---EQLDTLLCAHKQLAKL--DLHF			3308
ALVINELLA	3175	AANQONNFVVALKQMKa--TFNLVKGVNKT--LHIECYHEWTRIQHKKCKVASLT--tNEKIKALIE TMNVLEQRa-----			3245
CAPITELLA	3210	AASLQGNHSVARKLLKS--AKDLVKVVDSE--LSVFLTHSHANANKRCKASGSEP--sERLNLLEVEVKRLLDKC--SESST			3283
SPONGE	3219	AARTQSNYPVAENYLYKIVeKSIKLDPPDNYfIQRLWHLSLIKVRLDRIHQDPSPTdmeEAVISLTCQMDNFKGRlgSGSGK			3338
OYSTER	3256	SSCHKRNHLKALNLLAD--IHKNYRDKENEI--LNLWSHLYAKTHQLSAMSADTDwtndIFSSVITIDRLGKF--KDSLL			3291
SNAIL	3225	SCQEONNFNLTRILKE--TYSKCKREKSEL--LVVEWSHLYATHQKALSCSGIwskDMLYNVLSLTDPLSKV--AESKM			3300
TRICHOPLAX	3238	TARLQSNYPVAIKHLRQtLYHINQELDKDELTVKWTHTIYTKVHCDKSLTPPD---ERLKTLLTANSQFEKV--KDSL			3312
SEA ANEMONE	3229	AAREQSNFPVAHRYLREsLKSI--EDN--LHVKWTHAYAVTQKKAHGLMAT---DAVQTALSTVSKLQK--SINTL			3297
PRIAPULA	3264	SAMQQRNFPVALKHLRT--TNQLLKKLSDS--LAVQWTHSYVRTWQIATGHQRD--sadRLHRLDITIKELDKH--AGKAV			3338
ESHARK	3264	SGTKQRNFPVAMKLLKE--LHESKARDWA--VKWTHYSRSLSHRSRQARP---EQVTVLKSIPLLVEI--NVDY			3333
STERLET	3268	SARKQNNFVSATKLLKE--LHRESKNEEDWL---VRVHVSFRFSHTRSHTQSSS---EQLITVLTIPPLEER--KIDY			3337
COELACANTH	3262	SARKQNNFVSATKLLKE--LHRESKREBCL---TRVHVSFRFHSRSQSQSCP---ERIQVMKTIISLLES---KADY			3331
HUMAN	3245	SARKQNNFSLAMKLLKE--LHESKTRDDWL---VSVQSYCRLSHCRSRQGCCS---EQVLTVLTIVSLLEDN--NVSSY			3315
CAECILIAN	3265	SARKQNNFVSAMKLLK--LHRESKTRDDWS---VRVHVSCHYTHSRQSQTSP---DQVLSVITVSLLEET---KADY			3334
PLATYPUS	3253	SARSQNNFVAMKLLK--LHRESKTRDDWL---VRVHVSCHYTHSRQSQSSP---EKLLTVLTVSLLEDN--LSSY			3322
CANARY	3254	SARKQNSFAVAKLLK--LRKEARWEDWL---VRVNYACRFTTHSSRNLSCP---ERVLSVLTISLLEDT---KSDY			3323
OSTRICH	3224	SARKQNSFVAKLLKY--LHREAKTRDWL---VRVNYACRFTTHSSRNQSCP---EQVCSVLKTIISLLEDT---KSDY			3293
TURTLE	3263	SARKQNSFVAMKLLK--LHRESKTRDWL---LRVHVSCHYTHSRQSQNSP---EQMLTVLTIISLLEDN--KSDY			3332
ALLIGATOR	3221	SARKQNSFAVAKLLK--LHRESKTRDWSL---VRVHVSCHYTHSRQSQSSP---QQLLTVLTVSLLEDN--VPDH			3290
SOFTCORAL	3256	VATGQVNFPAVAKQLQSLHLIRDRLLKNDSELeVWTHSYGDLNCKKCPNLLPS---EAVDTAISALDQDKI--KDSKV			3330
STONYCORAL	3276	AAKEQGNVAVAHRCLEaLYKIPQGNEN--LNISSHTYAEVHFRKIQTTLAV---GAVETALLVAGQLDKF--SASKI			3347
ACORN WORM	3266	SVSQONNFVGAEKYLK--NCADAR--DDDA--WRLIWTLSYARLHQKCL--TLP--psKRVINLLTLDQLGMF--TEGC			3335
LANCELET	3278	SAREQANFPVALKHLKN--TLKDFP--EDDP--LRLRWTHCYARLHQKAS--LLT--gadKLNVLTFEQLDKF--SSCRV			3348
SEA URCHIN	3276	SACQONFVAVAKHLK--THRGLVEFED---LRPAWTHSYVSMTRKAL--LLK--pyERITSLKALDHLGKL--PVSHN			3346
STARFISH	3291	SACQGNFVAVAKHLK--THGSLSAHED---LKPKWTHSYVQMNQKIL--TIE--lkeQVMTLLTFDPLAKL--SNTPA			3361

Supplementary Figure 3: DNA-PKcs COBALT Metazoa Vertebrate Invertebrate

TERMITE	3214	PMLHAETLQHVSVMAAG---ILQLEQQPVL[1]-KLPAAEVKKLADR--IGAPdc---SQD	TLMQNLKQYGLSS	3278
SHRIMP	3270	LDQNRPRVEIQYKLESHLCLCRAIQDMGDDW[3]NQYMQVLSKPFENA--NGKESw---QRE	-----LSSCYKS	3336
SCORPION	3309	PKKLDVSTMMHYLLQSEIEMAADIVKYNDVHA	-----EKIQEL--TDTFS--iQSKS	3370
ALVINELLA	3246	-VDDSRVKCSQHILQQALFQLISLLKDDIHLV	-----DEYRNEIQNIthCGTYDh-----E	3309
CAPITELLA	3284	LKLNAAALCDQHLLQGEHLVMTATLQNQVKDI	DALDQKLEKITES--VGSALP---SHQ	3352
SPONGE	3339	AISSKPFISQHHVLLGKLLNMAEIFATPEDGM[3]SALSNDGNTKLNLSL-iGTPS---TSTK	AISEGLWIQALSS	3411
OYSTER	3292	FEREAGLGRHFVLLGQAFGLLVKGVQS-ENCF	SSLSDDKNSKIMGI--SKASK--LNPR	3359
SNAIL	3301	LREKPALGMRHMLLERSRTFDAVVTGLMS-VGNL	EELGDKTCEKLOQY--TK-SP---LNKG	3367
TRICHOPLAX	3313	ILENTTLRREHLLRSRLDMTSKILAESDASI	LDDLLEKKESLYQL-aNVNQH---DSKE	3382
SEA ANEMONE	3298	AN-DPVIALRHHLILRSRCPDILTDAIAGAG---	-----RSTLATYKLIcLINQP---VDKS[8]QIVSQLITRSFTS	3367
PRIAPULA	3339	LHQQRGLARENLLKGRSIEAVAREVLTRPASL	HTLPAATREKLSLV--AGARE---HDHT	3407
ESHARK	3334	LNTHTRILRDQNTLLGSSYCILADALNKPECTCL	QRIKEQDAERVIEH--SGSSS---BEIQ	3402
STERLET	3338	TKATRTRIVRDQNTLLGTYHYIMANALTRDGLAL	EHIGEDKAGKVLDDL--LGTTS---DNLE	3406
COELACANTH	3332	LKNKTRAFRNQNTLLGTYTYRIANALNKPTFSL	QDIEEKARKIQDL--SGAQS---DHPE	3400
HUMAN	3316	LSKNILAFRDQNTLLGTYTYRIANALSSEPAEL	AEIEEDKARRILEL--SGSSS---EDSE	3384
CAECILIAN	3335	LRNTREFARNQNTLLGTYTYRIANALCKDPRCL	QRIDKNKADKVLQL--SGTMS---ENPD	3403
PLATYPUS	3323	LSKNIVFRNQNLLGTYTYRIANALSKEPASL	EQIERNKARKVMEL--SGASF---DNVQ	3391
CANARY	3324	LSKNITMAFRNQNLLGTYTYRIANALSQDPRCL	EQIEEKARKKISLI--SGESL---ENPK	3392
OSTRICH	3294	LSKNTAFRNQNLLGTYTYRIADALSHDPRCL	EQIEEKARKKVSVL--SGESL---ESPE	3362
TURTLE	3333	LSKNIVAFRNQNLLGTYTYRIASALSQDPRCL	EQIEEKARKKVSML--SGERP---ENSE	3401
ALLIGATOR	3291	LSKNIEILRNQNLLGTYTYRIAMVALSKDPRCL	VELEEDKVRKVSML--SGEKP---DSPE	3359
SOFTCORAL	3331	LQENASTGIRHHLKSRNLDAITNVLSIPGTW-	DSLEKEAKEKLHGL-cSSKNP---EQLD	3399
STONYCORAL	3348	LEIEPLRGIQHHLILRSKTFDILCKAMLDGGVVI	ATLESQAKNALVKL-crIDET---ESQK	3417
ACORN WORM	3336	---EPSYRKKQHEIILSGRSCHLVAQTIQAGDDI[4]HLKCRKSLRSLIEA--LI-----	---VNLGNQKAHY	3396
LANCELET	3349	FEEEDLAVAKQHHTLTSLSYEIVAHALIQEGGAI[2]GLKDRHAQLLTA--GVSPP---TSVD	QTISSLLQKGHC	3419
SEA URCHIN	3347	LGSDFLCLDRHILTSKTYQSMASALQEGGEM[2]RLSDAG--KLDKL--LSKAECqesKPE	KVCQSLFMKSKY	3417
STARFISH	3362	LQGDYLLTRHHILTSKSYDLVAIAIQKGGADI[2]GLRNVGKLDKLLGL--VGQ---naTRPE	QICSTLYSKAYSE	3432
TERMITE	3279	LKTAEEVTPRGNs-----eQAVAKAHLQVAKYCRASNTSREDNFGTDI	-----VTSILRAMRYG	3334
SHRIMP	3337	LQLAVNCAEGLVKSDALNQDD--skSDSDAHLALVKYCEECVIKWKDHDVDSQY	-----SKSLMVSILRAMANG	3405
SCORPION	3371	KCRAIDI IQEVEQKMI EFDQAT-----IGETYPKFANYCNKILRMQEEEEKTSL	3]--SFETYPVSLTNSLLNALKNG	3440
ALVINELLA	3310	M-KAAVVFASDSSCSPTDKINM-----AHMALSYCYDTYLRQSENDESGQKI	3]--LSSFPAAVTVSLLAAMKNN	3377
CAPITELLA	3353	FKSGVGVAAASQPES-----V-----CVNKAYMSLVHFCQDQLRQRENDEISGTK[1]E	1]EEDDFPLALVTSLLSAMKNS	3418
SPONGE	3412	F-NAGVRSGLTFLNPLKDPVPT-----VQSLERLFGFCNDALRQEDHDEQSTG[1]	1]-DTKSFPSPSIIINHLLTAMSGL	3480
OYSTER	3360	MRKLSY--D-GRGTRTCRY----GLEEAAYLALAQYCNKFLRMAEDDTRKESL[4]	4]ECQKNFPEITITVCLLNAMKLD	3430
SNAIL	3368	LRKVISEVPED-SSRDVCLQ-----QDVLALAKYCDKYLRLAEBNDGL---[3]	3]ESMEVFPATAVKCLLDAMRAG	3435
TRICHOPLAX	3383	LHQAVKASK-----EE-RGG-----SSYIEAMMMVNFCDLILREHEEDGRAN---[5]	5]IDTKIFPEVIRYTLIEAMAYN	3449
SEA ANEMONE	3368	LQEAANKAAK-QAATSSSD-GST--TCMVEAMMAMVFCDRALRKEDESDGSPF[10]	10]FVQFPPEFVRYVLKAMEHG	3448
PRIAPULA	3408	LREAVDVGDEEESASLASSP-----SAAHVAMASYCDYFLVRREDDGTT---[1]	1]LPTDGYAETVITSLLRAMALG	3474
ESHARK	3403	LREAVRKAEEEVQSHSAGEHVDI---AGVIEAYMLANFCDRCLRKEEESATAINF	SEQOTFPACVVEKILKAMKYN	3475
STERLET	3407	LQNAVKKAEEELQSRSTEHDID---PGAIEAYMTLVNFCDKRLREEEESAEVSTF	SELPTFPVAVVDTMLKALKLN	3479
COELACANTH	3401	LQTAAKKAAEQVQSRSTEHDIV---AGVIEAYMTLVNFCDKRLREVEESAEVSHF	SELQTFPAVVVENLLRALKLN	3473
HUMAN	3385	LSEAVRKAEEEAQPPWSWCGPA---AGVIDAYMLVDFCDQLRKEEENASVIDS	AELQAYPALVVEKMLKALKLN	3457
CAECILIAN	3404	LDSAVKKAEEEVQSRAMENVDT---TGVIKAYMTLVNFCDTLLKKEDTAVVIDH	SHLQFPPTIVVEKMIKALKLN	3476
PLATYPUS	3392	LTHAVRKAEEEEEQSHSSEHVDI---GGVIDAYMLVDFCDKHLRNEEETSVIDA	VVLQAYPALVVEKMMKALKLN	3464
CANARY	3393	FSCAVRKTTEEVEQSSVDHVDI---VGVVDAYMLVDFCDQLRREEEGLEINT	VDLQFPFAIVVEKMIKALKLN	3465
OSTRICH	3363	FSSAVRKEEEVQSHSMEHVDI---AGVIDSYMTLVDFCDQLRREEEGLEINT	ADLQFPFAIVVEKMIKALKLN	3435
TURTLE	3402	FSTAVRKAEEEVQSHSMEHVDI---TGVIDAYMLVDFCDKHLRKEEESDVSVA	LDLQTFPFAIVVEKMIKALKLN	3474
ALLIGATOR	3360	LQNAVRKAEEESQSRMEHVN---TGVIDAYMLVDFCDKHLRKEEESGLSDISA	VDLQTFPTIVVEKMIKALKLN	3432
SOFTCORAL	3400	FORAIKIAQTENNQKNA-ESV---RNLVTSMTLVNFCDRLLRMEEDSEQ---[3]	3]LDMKLFPGIVIRFVLKSMAPF	3471
STONYCORAL	3418	LQSAIKAAK-NAEGKNC-TQT---SGTVDAMIAMVNFCDNLRKKEVS-----[5]	5]VDTKLFPFVIRYMLKSMCYS	3487
ACORN WORM	3397	FKKGVKLASDEEDA---IDM---drEGVIDAYVSMATFCDKMLKQEQNEDGAVS[2]	2]SKSPSPFRSrvPHLLKALKLN	3468
LANCELET	3420	LQKAVQAAEEDKARQDTSL---dksGIVDAPAMVFCCKILRHQEDDEEG--T[2]	2]SSIPGLAAAVVSNLLQALRHD	3492
SEA URCHIN	3418	LDDAVGTIKLDPASHLSSSAKreeQSMAKAHMALVDFCDQLRQDDDDCN-PD[2]	2]PLMEAYPSTVNVSTLQAMNLN	3494
STARFISH	3433	LKQAVSLADKDDAVTSQS-----eRSMTEAYMALVFCDRMLRLKESDEVPTMT[2]	2]PQTDNFSPQTVVHYTLKAMHYS	3503
TERMITE	3335	SKDARQLFPCLLQPLDTS-LSSELFHKESSAVPVWMLFGWVNLACLGTVPVGLHDIILRLAETYPQSLIYAFQLSR	3413	
SHRIMP	3406	SRDAHFHPRLINLMNEDA-SLSSFEKEEYKVPWMLLWLSHILYVDKVPQALQPVVERLAAEYPQAVIYPPGISK	3484	
SCORPION	3441	NLNAKFPRLQLIIEVYP-DTIPEFIAKSKVPCWMLGSINQLLTLDDKPEATAVQYIIEIGTNFPNALVYPPKLSY	3519	
ALVINELLA	3378	CSEARQRPRLQLTEQYP-ENMSLFIQKTSVPTWMLGWISQITALLDKPESPAIQDILKRLAVEYPPQAVVYPPKMSC	3456	
CAPITELLA	3419	SKDARQLFPRLQLIIEVYP-QTRVFIKRSRDIIPAMWMLGWISQICALLDKPESPAIHEILINADIYPNALVYPPKLSN	3497	
SPONGE	3481	SSKARELFPRLQLVEAHP-DTMDLINSKSTIPCWMLGWISQIMIALVVKPESRAVHDILIRIADTYPQSLIYAFRMS	3559	
OYSTER	3431	SMEARQRPRLQLVEMYP-EIRSTFVBEKQVPCWMLMWISQIMALLDKPEGSTVHHILTELAETYPQAVVYPPKLS	3509	
SNAIL	3436	SAEALERFPRLQLIIEHYD-DTDMFLKKSSTIPSWMLLWISQIMALLDKHQAHAVRPIILRIATEYPQAVIYPPHISQ	3514	
TRICHOPLAX	3450	SMDARQRPRLQLIIEVYRNP-NTIDGFMKRSAPISWMLIGWISQIMALLDKPEARAVQBIILFRIADEYPAIYAFKVS	3528	
SEA ANEMONE	3449	SEEARNRPRLQLIIEVYRNP-TLDSFVVKVEVTPCWMLIGWISQIMVALMDKKEARAVHGIIVTEIAKNYPQALCYAFKVS	3527	
PRIAPULA	3475	SSEARDSFPRLQLIIEVYRNP-DTLPPLTSKVESVPCWMLIGWISQIMVALMDKREARAVQGLLSIAESYPQALYPLNRS	3553	
ESHARK	3476	SKEARLFPRLQLIIEVYRNP-ETLDMKKEVSVPCWQFVIGWISQIMVALMDKKEAVVQHIIEEIAESYPQAVIYVPLMIS	3555	
STERLET	3480	SKEARLFPRLQLIIEVYRNP-ETLDMKKEVSVPCWQFVIGWISQIMVALMDKKEAVAVQHIIEEIAEYYPQAVIYVPMIS	3559	
COELACANTH	3474	SREARLFPRLQLIIEVYRNP-ETLDMKMGVSVPCWQFVIGWISQIMALLDKKEAVAVQHIIEEIAESYPQAVIYVPMIS	3553	
HUMAN	3458	SNEARLFPRLQLIIEVYRNP-ETLSLMTKEISSVPCWQFVIGWISQIMVALMDKQAVAVQHSVEEITDNPQAVIYVPMIS	3537	
CAECILIAN	3477	SKDARLFPRLQLIIEVYRNP-ETLDMTKEISSVPCWQFVIGWISQIMVALMDKKEAVAVQHIIEEIAEYYPQAVIYVPMIS	3556	
PLATYPUS	3465	SREARLFPRLQLIIEVYRNP-ETLDMTQEISSVPCWQFVIGWISQIMVALMDKKEAVAVQHIIEEIAEYYPQAVIYVPMIS	3544	
CANARY	3466	SREARLFPRLQLIIEVYRNP-ETLGLVTOELSSVPCWQFVIGWISQIMVALMDKDEAVAVQHIIEEIAEYYPQAVIYVPMIS	3545	
OSTRICH	3436	SREARLFPRLQLIIEVYRNP-ETLGLVTRVLSVPCWQFVIGWISQIMALLDKDEAVAVQHIIEEIAEYYPQAVIYVPMIS	3515	
TURTLE	3475	SRDARLFPRLQLIIEVYRNP-ETLGLMAREISSVPCWQFVIGWISQIMVALMDKKEAVAVQHIIEEIAEYYPQAVIYVPMIS	3554	
ALLIGATOR	3433	SREARLFPRLQLIIEVYRNP-ETLSLMAQEIISVPCWQFVIGWISQIMVALMDKDEAVAVHHTVEEIAHNPQAVIYVPMIS	3512	
SOFTCORAL	3478	SAEARKFPRLQLIIEVYRNP-GDIEAFKRKSSVPCWQFVIGWISQIMVALMDKREHAVQGIQLDIAKHYYPQAVIYVPMIS	3551	
STONYCORAL	3482	SKEARQFPRLQLIIEVYRNP-TLEAFVKKAADVPCWMLIGWISQIMVALMDKDEAVAVQHIIEEIAEYYPQAVIYVPMIS	3566	
ACORN WORM	3469	SVEARQFPRLQLIIEVYRNP-DTMDTFVELTSETPCWMLIGWISQIMVALMDKVEISVQGIILIEIANYPQAVIYVPMIS	3547	
LANCELET	3493	SPEARQFPRLQLIIEVYRNP-DTMDLFIKESVHPVSWLCSWGLQMVALLDKPEARAVHGIILTRIAEQYYPQAVIYVPMIS	3571	
SEA URCHIN	3495	SPEARQFPRLQLIIEVYRNP-DTMOQLVKKASIIIPSWMLIGWISQIMVALMDKPESLAVQGLLKAIAKDYYPQAVIYVPMIS	3573	
STARFISH	3504	SQEARQFPRLQLIIEVYRNP-DTMOQLMIKESVPCWMLIGWISQIMVALMDKPEGPAVHGILTDIAEYYPQALCFPPKISS	3582	

Supplementary Figure 3: DNA-PKcs COBALT Metazoa Vertebrate Invertebrate

TERMITE	3414	EKYNLESGHVSL--KALVDQLASLFTD--PV--IDIFLRAFSCLGQPRKMLYHFVEKLEQLLNA	KRPNC---DSLH	3481
SHRIMP	3485	QQYNF--SSHEGKLAAMCDKVEALSSHk--L--LHQFVSAMSLMVPVSIACKDAIQNVLQEKDK	QKMEE----GLS	3552
SCORPION	3520	EMYKFPDPLQCKENKEFVVKMLKSSLSQk--L--VDFVNALDLSVPELLEYKEYFKEILQMKKD	-KGDG---NEIV	3588
ALVINELLA	3457	DGYKFSNDEQKKAAMVIRVNEELSKN--PL--IGKFINALEQLGQPDLSFKDWYQNLWEKECF [2]	PEKNK---THIL	3528
CAPITELLA	3498	HNYKFTSDAVSSKSKVCDRLHQMLSKN--PL--IDRLIFSLMMHPEPAVLIKDWIMDMKNKAGP [2]	SSQSL--smAYVK	3571
SPONGE	3560	SGYKFGHN--NSEGKELFEKLEKQLSQ--L--MDEFIAALEQLNSPELAWKDWYDNLKPLV [4]	PKRDK---NAIK	3630
OYSTER	3510	EGYKF--TNNKDEAFVTKLSTLGDqLPL--VPKFISALEHMSQPDQIFKDFDDTRLK--F [2]	NKPKD--ka--MK	3577
SNAIL	3515	ESFTFGSTAEARRNKQGIIEELDALLSEErVPL--VRTFTISALEQFSQVPMFQDWSRDTI-K--I [2]	KRPAA--e---IK	3584
TRICHOPLAX	3529	EQYTFEETSVGRQNKFAVSKLSSKLQL--PL--IESFVRALEQLSQPDLVFKDWVDE--VKGL-K	KKSGS--iaESIR	3597
SEA ANEMONE	3528	EQFVFDSSPEGNTNRKAVERIKRLLES--PL--MDSFIAALEQLHNPMAFKDWDCGEIKQLLQ	TKNKK----AIK	3595
PRIAPULA	3554	EHYTFVDAAGAEAEAYLHRLLATLSTC--mdMSqLQQLVASLEQLSSPHMLFSDFVADARPLM- [1]	RRADF--pa--RFR	3627
ESHARK	3556	ESYTFEQTARGNTNKEFVRLKNDLKG--GM--VEVFINSLEQLSNPDLFKDWVDFNRSKLEK	KE--NK---TQLK	3624
STERLET	3560	ENYVFEEDSATGHRNKEFVARLKSQLDKG--GV--VKNFIDALQQLTNPMLFKDWVDEVKKLEK	PKTDC---KLLK	3629
COELACANTH	3554	ESYSFPEESPCKRQNKFAVSKLSSKLQL--PL--IESFVRALEQLSQPDLVFKDWVDE--VKGL-K	PQRNK---ANLK	3623
HUMAN	3538	ESYSFKDTSTGHNKEFVARIKSKLDQG--GV--IQDFINALDQLSNPELLFKDWSDVRLELAK	TPVNK---KNIE	3607
CAECILIAN	3557	ENYSFEDTATGHNKEFVARIKSKLDKG--GM--VQDFIQSLEQLSNPDMFKDWIEDMKNELAK	SQRNK---NNIK	3626
PLATYBUS	3545	ENYSFKDTSAGHNKEFVTRIKSKLDKG--GV--VQDFIQALEQLSNPEMLFKDWVDEIKIELTK	TPINK---NNLK	3614
CANARY	3546	ESYCFKDTAAGCKNKEFVERIKSKLDKG--GV--VQDFVHSLEQLSNPVMFKDWVDEVRNLSK	PQRNK---KLLK	3615
OSTRICH	3516	ESYSFPEETVTCGNKKEFVARIKSKLDQG--GV--VQDFVHSLEQLSNPMLFKDWVDEVRNLSK	TQRNK---NNLK	3624
TURTLE	3555	ENYSFKDTSAGHNKEFVARIKSKLDKG--GV--VQDFVHSLEQLSNPMLFKDWVDEVRNLSK	TQRNK---NNLK	3624
ALLIGATOR	3513	ENYSFKDTSAGHNKEFVARIKSKLDQG--GV--VQDFVHSLEQLSNPMLFKDWVDEVRNLSK	AQRNK---AKLK	3582
SOFTCORAL	3552	EQFKFGGSIIEQKNKEFVSLNESLSP---PA--SDDLQALEQLTNPMLFKDWVDE--VKVLLS	TKGNA---VKLR	3619
STONYCORAL	3567	EHFVFEEDSATGHRNKEFVARLKSQLDKG--GV--VKNFIDALQQLTNPMLFKDWVDEVKKLEK	PKTDC---KLLK	3629
ACORN WORM	3548	ENYSFPEETVTCGNKKEFVARIKSKLDQG--GV--VQDFVHSLEQLSNPMLFKDWVDEVRNLSK	TQRNK---NNLK	3624
LANCELET	3572	ENYFPEEDSVTCGNKKEFVARIKSKLDQG--GV--VQDFVHSLEQLSNPMLFKDWVDEVRNLSK	TQRNK---NNLK	3624
SEA URCHIN	3574	EDFKLGDKSKEKRDVAVKIEIDILSTV--PL--VENLITLALQRLTHPQFIFKDWISVINKMN- [2]	ERDHP--a--IK	3643
STARFISH	3583	ESFTFDESNTGRKNASARKIGAILLES I--PL--LDDFICALEQLNNPEFVKDWISVINKMN- [2]	AKRDK--nk--IR	3653
TERMITE	3482	HMVDTMMK-ELFPSS [1]--gkiHGALf-----KDIQYRKRLEK--AESNICKGNKKVLDKICFIKEKLYIIQ [2]		3546
SHRIMP	3553	EIVSEFLK--VQNR [3]NaekGEAYT-----RDRAKQMAEAFTKAFGENLKKASLS-IRDIQRELGSMDRVLQ [3]		3625
SCORPION	3589	KLYKKLCH-ELFNYN [1]RDkmkERKlhl-----KVAKCGSVVFPSEFGKDGKLIIMP-LKEASVYETLLKKIT [2]		3657
ALVINELLA	3529	THYKDMYD-QLLATE [1]-----ndKGPYTRFAEYRDRFNHAFGTGGEKQQFT-YAKFQEEGNKILQKIN [3]		3595
CAPITELLA	3572	ERYQELRY-KLLCIE [2]DgslYSDSAdcsMGPYRSDVVKQFISQFDEYFGKMGSKIPGLT----FMKVLWSLSDKSE [6]		3649
SPONGE	3631	RVNEQMS-QLLETR [6]SLyggSPSLq--KGARQTFPAQYAKNIEDKFGKGAKISMS-GTQLASAFNEVYNKMR [3]		3710
OYSTER	3578	QTeetLSMvd--KGYPKRFAERFKKDVSDCFGNKGEKILDMs---FSKLAGAYKVKYK [7]		3663
SNAIL	3585	KKYKEIYD-MLEEM- [12]QT--sFgAVs--MGFHRRAEAVFKNEFDNHFGVDSKLVMT-----AKFSGILRNL-- [7]		3666
TRICHOPLAX	3598	ICYQLRDLGLVDAS [4]AasslTSGEliefGSHKRRFIQHFQKVIQYFQKDGSKLQMS-ASDFEKIASRLIQEIS [1]		3676
SEA ANEMONE	3596	EAFRSIYK-ALGDFS [4]TDssqPAAE--emGPFRRFVSKHSHARFENIFGKDGKLVNMS-LKTAK----LQKQMV		3665
PRIAPULA	3628	KIYASLFD-TTRR-- [2]EE---PG-g--RGRYWSVTRTWAREVEEKCGRDGSKLLAMA-AADANQVLSALGKEMK		3693
ESHARK	3625	NLYSEMYS-NLANAG-----APGI---GAFRRRFTGFKKKIQDFHGKDLGLLNMN-LKAFNVAVGQIMETQ-		3687
STERLET	3630	NMYEMYS-ALGNPR-----CQGI---GAFRRKFAQHFSEKFDKTFGKGAKLFDK-HDAFRKASDSLWGSIS [2]		3695
COELACANTH	3624	RMYEMYA-NLGNLR-----APGL---GSFRSNFVKAYGKEFERYGKRGKLLDMK-SSDFPKVSDQLTSM-		3686
HUMAN	3608	KMYEMRY-ALGDPK-----APGL---GAFRRRFTGFKGKDFKHFGGSKLLRMK-LSDFNIDITNMLLLKM-		3670
CAECILIAN	3627	KIYEMYM-NLGNLK-----APGI---GAFRRRFTGFKGKDFKHFGGSKLLRMK-LSDFNIDITNMLLLKM-		3689
PLATYBUS	3615	RYEMMYK-TLGNLF-----APGL---GAFRRRFTGFKGKDFKHFGGSKLLRMK-LSDFNIDITNMLLLKM-		3677
CANARY	3616	MYERMYK-NLGNLE-----SPGL---GMMRKRFIQAFGKDLDFHFGGSELLNMK-TSDFDAIANSLSHSM-		3678
OSTRICH	3586	DMYERMY-NLGNLE-----APGL---GLLRRRFTGFKGKDFKHFGGSKLLRMK-LSDFNIDITNMLLLKM-		3648
TURTLE	3625	MYEMMYR-NLGLDQ-----APGL---GLLRRRFTGFKGKDFKHFGGSKLLRMK-LSDFNIDITNMLLLKM-		3687
ALLIGATOR	3628	MYEGMYG-NLGNLQ-----ASGL---GLLRRRFTGFKGKDFKHFGGSKLLRMK-LSDFNIDITNMLLLKM-		3645
SOFTCORAL	3580	ESYEGMSK-KLLNVK KRgtnSDGL--eFGSIRRRFAEFSGNVVKVCGEDGSKIDMS-IKAFESAMKTITNEKMK [1]		3691
STONYCORAL	3639	QCFGAMFQ-LLMDCR [3]KSgsqTRGT--eSGPFRTKFAQEFANEVQRIFGKEGKLVGVK-MTDFSKWCRDIQQK [2]		3714
ACORN WORM	3621	GLYTRVFD-S----- [12]DSdavTQSLp--FGPFQKFAFDVFKPFQKRFGERGCKLISMqHQKEFMNFRNEVDQLM [1]		3699
LANCELET	3650	LYDDEMYD-LLDLFR [15]SSdesQSVg--FGPFRFRFAQFQFAKECEKMFQKDGSRILDMK-LSDFNIDITNMLLLKM [10]		3745
SEA URCHIN	3644	QYQQLYQ-QLF--- [11]SS-----QTVe--PGPYWKFGRWQKRFDSFQDGSKLAAMD-YKTWS---KLQDQIC [3]		3717
STARFISH	3654	QACHEIYM-NLINH [15]SS-----PSVg--FGNFRFRFAQEWQKFAAFGKDGTKVIDMQ-LKTFSEHYGKLYKEMA [3]		3738
TERMITE	3547	---KPPVQLKDYSPWLSEFGgKHCFLLELEIPGQYTGESKPLIQHHVKIAGFKQTVVPMKTLRLPLQVTFIIGSDAKEHQ		3622
SHRIMP	3626	EBMRKLPRLQKAYSPWANFQA-SKYSVLELPGQYTGMSKPLPEYHVKISSFDENVLLMSMRVPMRIIRGDDEKEYK		3704
SCORPION	3658	-SEMNKELRLRDFSDLSEFHS-IKYSEIDIEIPGQYTGKRRKPIPEHHVKICNFQKVDLILSLTKPRCLTIRGNDQKDYK		3735
ALVINELLA	3596	---KPPEDIAEYSEWANFQA-CEFDQIEIPGQYIGKAKPLPYHTKISSFHSVVKTLQSMRKPKRIVIRGNDQKEYP		3670
CAPITELLA	3650	--SNKQPRKLEYSQWLABFQA-GNHEASLEIPGQYTGVEVCLPEYHAKISSFDQVTVLRSRMPKSIIVIRGNDQKEYP		3726
SPONGE	3711	-NKFSSALLKDYSPWLDTRFQ-EDYLVQIEVPGYDGRSKPLPEYHAKITRFDKVLILSLRKPRLTIIGDDTREYM		3788
OYSTER	3664	EKNLPPANLKDYQWLANFNP-SIQGKLEIPGQYDGVKPMPEYHAKIVGFDQRVVMTSIRKPKRITIRGNDQKEYP		3742
SNAIL	3667	KADLTPPTNIGKYCSWMANFNP-NHESRELEIPGQYDGRSKPLPEYHAKIVGFDQRVVMTSIRKPKRITIRGNDQKEYP		3745
TRICHOPLAX	3677	-KIKNRPENLKEYCPWLSNFQA-ANFTYSIEVPGQYTGSRKPLPEYHAKISGFERLLVLSIRKPLRLTVQGDDEKEYL		3754
SEA ANEMONE	3666	---SKPPGNLKEYSPWLTNFQA-DSHAQKLEVPQYTGQSKPMPEYHVNIAGFDEKVLVLSIRKPKRVTIRGDDERDHY		3741
PRIAPULA	3694	TKAADSPGNLKEYSTWLTDFHS-SPATCQIEIPGQYDGRSKPMPEYHAKIAGFDEKVLVLSIRKPKRITIRGDDERDHY		3772
ESHARK	3688	-KPEPPGNLKEYSPWMSNFKP-QFLGNELEIPGQYDGVKPMPEYHAKITGFDERVKVMSIRKPKRITIRGNDQKEYP		3764
STERLET	3696	QKKEPEPNLKEYSPWMSNFKP-EVLRNELEIPGQYDGVKPMPEYHAKITGFDERVKVMSIRKPKRITIRGNDQKEYP		3774
COELACANTH	3687	RKFQREPGLKEYSPWMSQFKP-EFLRNELEIPGQYDGVKPMPEYHAKITGFDERVKVMSIRKPKRITIRGNDQKEYP		3765
HUMAN	3671	NKDSKPPGNLKEYSPWMSDFKV-EFLRNELEIPGQYDGVKPMPEYHVRIAGFDERVTVMASLRPKRITIRGDDERDHY		3749
CAECILIAN	3690	RGSQPEPNLKEYSPWMSNFKP-EFLRNELEIPGQYDGRSKPMPEYHAKISGFDERVKVMSIRKPKRITIRGNDQKEYP		3768
PLATYBUS	3678	KESSKPPGNLKEYSPWLSDFRV-EFLRSELEIPGQYDGVKPMPEYHAKITGFDERVKVMSIRKPKRITIRGDDERDHY		3756
CANARY	3679	IKTHKEPNLKEYSPWMSNFKP-EVLRNELEIPGQYDGVKPMPEYHAKISGFDERVKVMSIRKPKRITIRGDDERDHY		3757
OSTRICH	3649	TKSHKEPNLKEYSPWMSNFKP-EVLRNELEIPGQYDGVKPMPEYHVRIAGFDERVKVMSIRKPKRITIRGDDERDHY		3727
TURTLE	3688	KD-QKEPNLKEYSPWMSDFKA-EFMRNELEIPGQYDGVKPMPEYHAKISGFDERVKVMSIRKPKRITIRGDDERDHY		3765
ALLIGATOR	3646	RDGQREPGLKEYSPWLSDFKA-EFMRNELEIPGQYDGVKPMPEYHAKISGFDERVKVMSIRKPKRITIRGDDERDHY		3724
SOFTCORAL	3692	---KPFVGNLKYSPWANFQT-QSETIQLEIPGQYSGQSKPLPEYHVKIVGFEKVKVMSLRAPKRITIRGDDERDHY		3767
STONYCORAL	3715	RNRTPPPGNLKEYSPWLSDFQS--NNFTHTLEIPGQYDGVKPMPEYHAKIVGFEKVKVMSLRAPKRITIRGDDERDHY		3793
ACORN WORM	3700	KKKMSAPGNLKEYSPWLSDFQP--INYEKELEIPGQYKGRSKPLPEYHVKIVGFEKVKVMSLRAPKRITIRGDDERDHY		3778
LANCELET	3746	KANCYAPGLLKYCPWLSDFNP-LDYDRELEIPGQYTGKVKPLMZYHAKIAGFDRVQVMSLRAPKRITIRGDDERDHY		3824
SEA URCHIN	3718	TPGKDDPNLKEYSPWTFATQT-LRGD-ELEIPGQYDGVKPMPEYHVKIVGFEKVKVMSLRAPKRITIRGDDERDHY		3795
STARFISH	3739	---RDPGNLKEYSPWTFDFQ--LSYDRELEIPGQYDGVKPMPEYHVKIVGFEKVKVMSLRAPKRITIRGDDERDHY		3814

Supplementary Figure 3: DNA-PKcs COBALT Metazoa Vertebrate Invertebrate

TERMITE	3848	TGLFRETMIHCLRTLRLNNDYDMLLATMEVFVQEPSIDWLEFASRHESLNKKSHEESQT-	---	WYPQKLDLAKLKE	3919
SHRIMP	3919	VGMLREIMVSLGALQESRHLVLTAVLEAFVKEPKDWLDFVQKQ-----EGDTQ[	2]	KVELFSSKRIELLNDKLS	3987
SCORPION	3963	KGVIEATMISALSAALRDNADILLNTMDIFIKEPTVNWQENALKQKRIIGKVDENVDSD[	18]	DFNWYPKQRILFAKRRKE	4056
ALVINELLA	3898	KGLFESTMIHVLRALRDNQDIIINTMDVFIKEPSLDWQANMRELNQMQSCDENHEDI[	17]	DPHWYPAKAVAFACRKLN	3990
CAPITELLA	3957	KGVIEGTMVHSLRALRQHKELISTMDVFIKEPSLDWQNAAKKEIQAMSNRKEBTSKL[	2]	DSQWFPKQKVNIVRQKLE	4034
SPONGE	4011	SGQLRSCMIHTLRLALRHSPTLLNTMDVFIKEPSLEWESNAKKQALA----QKINTD		DNTWYPKEKVNICRKKLL	4081
OYSTER	3966	HGLMESTMIHVLRALRNCDDLNTMDVFIKEPSLDWLVNAEKQMNEMKVEVSPEDDEV		--QWYPKEKIEYVRRKLR	4039
SNAIL	3973	KGLLENTMIHVLHALRQNHDDLSTMDVFIKEPSLDWLFQAFERQMRGGMGPKDAEDDM		--RWYPKQKIEAARAKLK	4046
TRICHOPLAX	3983	NGQLCSVMHVLRALRNPDDLNTMDVFIKEPSLDWQNFANRQNAKQG--LKTESD-		DFSWYPREKVTFAKRRKL	4055
SEA ANEMONE	3961	SGLVNRTMIHVMRALRGNHELLNTMDVFIKEPSLDWQMFARKQAEDQHMEIGMYE-		DLTWYPREKVLTAQRKLE	4035
PRIAPULA	4011	RGLLYQTMVHTLRLALRDNHRLLLNTLDVFIKEPSIDWKATAERLADKDIHSNESDQGE[	1]	VQEWYPKQITIGVARSKLI	4087
ESHARK	3990	SGLIRSIMVHGLRAFRLDPDLLSTMDVFIKEPSLDWKNLELQMKKGGTWNKDVNTR		EIHWYPMQKRVYARRKLE	4065
STERLET	3999	SGQIYSVMVHSLRAYRADPDLNTMDVFIKEPSLDWKNFELKQMKKAGSWEAVNTK		EINWYPMQKVNFAARRKLE	4074
COELACANTH	3996	QGLIYSVMVHSLRAYRNPDDLNTMDVFIKEPSLDWKNFELKQLKKGGSWTKEVNTK		DFSWYPLQKVKCGRRKLE	4071
HUMAN	3977	TGLMYSIMVHALRAFRLSDPGLLNTMDVFIKEPSLDWKNFEQKMLKKGGSWQIEINVA		EKNWYPRQKICYARRKLA	4052
CAECILIAN	3992	SGLIYSVMVHALRAYRTPDPLNTMDVFIKEPSLDWKNFELKQLKKGGSWTKEVNTA		EKNWYAVQKVNCAARRKLA	4067
PLATYPUS	3984	SGLVYSVMVHALRAFRLDPDDLNTMDVFIKEPSLDWKNFELKMLKKGGSWTKEVNTA		DTNWYPLQKISYARRKLT	4059
CANARY	3985	WGLIYSVMVHALRAYRSDPDLNTMDVFIKEPSLDWKNFEQKQLKKGGSWTKEINTS		EVNWYPLQKVNVRARRKLT	4060
OSTRICH	3955	DGLIYSVMVHALRAYRNPDDLNTMDVFIKEPSLDWKNFEQKQLKKGGSWTKEINTS		EVNWYPLQKVNVRARRKLT	4030
TURTLE	3993	SGLIYSVMVHSLRAYRTEPDLVSTMDVFIKEPSLDWQNFELKQLKKGGSWTKEVNTA		EINWYPLQKVNCAARRKLA	4068
ALLIGATOR	3953	SGLIYSIMTHALRAYRNPDDLNTMDVFIKEPSLDWKNFELRLKKGGSWTKEVNTC		EVNWYPLQKVNCAARRKLA	4028
SOFTCORAL	3995	SGQLQSTMVYTMRALRNNHEILLNTMDVFIKEPSLDWQNFARKQAQAEKQKLNLDNM-T-		DLAWYPKKINSARRKLE	4068
STONYCORAL	4022	SGTLQSVMIHTLRLALRSHDDLNTMDVFIKEPSLDWQNYARKQAKTQG--INEEQ-		KADWYPKQKVSARRKLE	4094
ACORN WORM	4007	DGLIYSVMVHGLRALRNPDDLNTMDVFIKEPSLDWQ----KRAKSDASKYGDAA--[	5]	MIERYPKADRIINARRKLE	4081
LANCELET	4055	SGLLQSTMVHVLRALRSPNVLNTMDVFIKEPHLDWK----NFAAKQMDKGMVGE--[	5]	DISWYPREKIKFAARRKLE	4129
SEA URCHIN	4025	DGVLQSTMVHTLRLALRQHELLNTMDVFIKEPSLDWKNFAVKQADYQKLS-----[	5]	DISWYPKKIKFAARRKLE	4098
STARFISH	4044	BGILQSSMVHTLRLALRQHELLNTMDVFIKEPSLDWKNFASKQAQAKQKADAGRVLQEQ[	8]	DESWYPREKVNFAARRKLE	4127
TERMITE	3920	GANPVTITTEELKAGF	KDSKYLAKFLECVKG--HNSVRSQMPSYQLPEEQVDSLLDQATDYNILGKTWQGWEPWM	3993	
SHRIMP	3988	DINPAYITLWAVSQNK[	2]AKQKAYENLQVVLGDRGESVRSVGERGLSTHQVDILLEQATDPNILGRSWIGWDFPL	4065	
SCORPION	4057	GINPCYITKEELRIGH	SNKPIFQRLTVDCLGDRK--SLRQNLPKNGLSVKQVKSLLIDQATDSDGILSRIFYGWDPWF	4131	
ALVINELLA	3991	GHNPAHITRDELVQGH	KGKTYCCKAAKVVLGDPHEHDIRAKLPPKCLTVEEQVAACLINQATDGNILSRVFCGWEPWM	4066	
CAPITELLA	4035	GSNPSHVMRAELALGQ[	2]---SYLKYFVIVLMDGKQADIRARLPADGLSSEEQVAALLNLTADPNILGRTFAGWEPVW	4109	
SPONGE	4082	GFNSHMLMLIDLEHGF	KNKPEFKYLKGLLGDSTNLRARVGRKCDSEVDQVDCLDHATDSNVLGRTYGWEAWV	4157	
OYSTER	4040	GDNPCVISREBELKIGH	SKKPAFPALEVRVLQGDKRENVRARQLPASGLTVEQVAALIDQATDPNIVGRVWGWEPWM	4115	
SNAIL	4047	GDNPSYITRDELRLIGH	LRNQAALKDFEVALGDVQDNIRARLKEKGLTEEQVAALIDQATDPNILGRVWGWEPWL	4122	
TRICHOPLAX	4056	GANPAFVTRDELRLIGH	H---LSILESALGDKQYNERARMPADNLSEVDQVTCCLIDQATDPNILGRWGWEPWM	4127	
SEA ANEMONE	4036	GANPAFVTRDELRLIGH	RRRSWFRNLQSAACLDGRRHNVRAQKEENELTSEAQVDCCLIDQATDPNIVGRVWGWEPWM	4111	
PRIAPULA	4088	GANPAHITKAEALALGH	RKHEALQMTNVAVLGDRPSDLRAQLPPEGLTVEQVQVCIIEQATEPSLLGRTWGWEPWM	4163	
ESHARK	4066	GANPAAITRDELRLIGH	ETTEAYKSYVAVMGDKHEHNRARVPEGLSVEIQVDCCLIDQATDPNIVGRVWGWEPWM	4141	
STERLET	4075	GANPAVITSEELKLG	EKSPAYQSI IAVAQGEKHNVRAREAPQGLSVETQVECLIDQATDPNILGRVWGWESVW	4150	
COELACANTH	4072	GVNPIVITCNELRLIGH	EKLSAYQSYLAVVKGDPDHNVRAREVKEDLPVETQVACLIDQATDPNIVGRVWGWEPWM	4147	
HUMAN	4053	GANPAVITCELELLGH	EKAPAFRDYVAVARGSKDHNIRAEPESEGLSEETQVKCLMDQATDPNIVGRVWGWEPWM	4128	
CAECILIAN	4068	GNPAAITCELELLGH	EKSVAYKEMKAVAMGDKTHNVRAREPKDGLTEETIQVKCLLDQATDPNIVGRVWGWEPWM	4143	
PLATYPUS	4060	GNPAAITCELELLGH	EKVPAFGDYISVARGSKDHNVRARQPEEGLSEEQVQVCLIDQATDPNIVGRVWGWEPWM	4135	
CANARY	4061	GANPAITCELELLGH	ERSPAYNDFAAVARGNSNHDIRAKEPEDGLSEETQVRCCLIDQATDPNIVGRVWGWEPWM	4136	
OSTRICH	4031	GCNPGRITCELELLGH	EKSPFFSDFVAVARGNAAHNTRAKEPEDGLSEETQVKCLIDQATDPNIVGRVWGWEPWM	4106	
TURTLE	4069	GANPAVITCELELLGH	EKSPAYKEYVAVARGSRDHNIRAKEPEDGLSEETQVRCCLIDQATDPNIVGRVWGWEPWM	4144	
ALLIGATOR	4029	GSNPAAITCELELLGH	EKSLAYRDYVAVARGTRDQNIIRAKEPEDGLTEETQVKCLIDQATDPNIVGRVWGWESWM	4104	
SOFTCORAL	4069	GNPAAITCELELLGH	KKAGYIEMLSVLLGDRQNRARHYVN--TVENQVACLIDQATDPNIVGRVWGWEPVW	4142	
STONYCORAL	4095	GFNPAYVMRDLDLQGH	SKQSWYKQMESVCLGDRNANVRAREPESEGLSVESQVSCCLIDQATDANILGRWGWEPVW	4170	
ACORN WORM	4082	GANPCHITRDELKLM--[	3]IKKHYCTGYIDVCMGDKKYSMRTREPATGLSVEKQVACLVDQATDPNIVGRVWGWEPVW	4158	
LANCELET	4130	GVNPTHITKAEELQGH[	4]WFKSFCL----VAMGDGKDVRAQKPAEGLSVEDQVACLIDQATDPNIVGRWGWQSFM	4205	
SEA URCHIN	4099	GVNSTYITKAEELMGP[	4]ARDAPFLKALKSTCGGNTESKRAQSKSKGLSVEDQVACLIDQATDPNIVGRVWGWEPVW	4178	
STARFISH	4128	GANPSDITQRELLALGH	SRNPAFSAIKEVVLGDRSQNIRASSPKSGLSVETQVECLIDQATDPNIVGRVWGWEPVW	4203	