

驅動蛋白之間的演化關係

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摘要

驅動蛋白是納米尺度的生物分子馬達。在一系列研究中，科學家發現驅動蛋白是透過一個行走機制來沿微管運動，很像一個走鋼絲者沿一條鋼絲走動一樣。藉由本文的研究，期望能將驅動蛋白序列之間所透露的生物資訊傳遞給更多熱愛研究生物分子馬達的人。

關鍵詞：驅動蛋白，生物分子馬達，生物資訊

Evolutionary Relationships Between Kinesins

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ABSTRACT

Kinesin is nanoscale biomolecular motor. A series of studies has discovered that kinesins transport cellular cargo to their respective destinations along microtubules using a walking mechanism similar to that of a tightrope walker. My aim in this study was to convey the biological information obtained from the protein sequences of kinesins, as it pertains to biomolecular motors.

Key Words: kinesin, biomolecular motor, biological information

一、前言

微管是一種具有極性的細胞骨架。微管是由 α 和 β 兩種類型的微管蛋白亞基所形成的。而與微管結合而起運輸作用的生物分子馬達蛋白可分為驅動蛋白（Kinesin）與動力蛋白（Dynein）這兩大類，兩者均需ATP提供運輸能量。驅動蛋白最早在章魚及哺乳動物的腦中所發現[1]，是由兩條輕鏈和兩條重鏈構成的四聚體，外觀為具有兩個ATP酶活性的球形頭和一個螺旋狀的桿與兩個扇子狀的尾所構成，驅動蛋白透過結合和水解ATP，導致頸部發生構形改變，使兩個頭部交替與微管結合，從而沿微管行走，將尾部結合的貨物（如：運輸泡或細胞器）轉運到其他地方，而驅動蛋白的基本結構

及其行走機制如圖1所示[2]。在本文中使用的驅動蛋白序列進行分析，並進一步去得到驅動蛋白序列之間的相關訊息。

二、序列分析方法

本研究使用十三種驅動蛋白進行序列分析，這十三種驅動蛋白分別為熱帶家蚊驅動蛋白（*Culex quinquefasciatus* kinesin, Accession Number = EDS35204）[3]、奈氏阿米巴原蟲驅動蛋白（*Naegleria gruberi* kinesin, Accession Number = EFC43561）[4]、埃及斑蚊驅動蛋白（*Aedes aegypti* kinesin, Accession Number = XP_001653597）[5]、粉色麵包黴菌驅動蛋白（*Neurospora crassa* kinesin, Accession Number

= AAB52961) [6]、玉米小斑病菌驅動蛋白 (Bipolaris maydis kinesin, Accession Number = AAO59295) [7]、富克葡萄孢盤菌驅動蛋白 (Botryotinia fuckeliana kinesin, Accession Number = AAO59277) [7]、玉米黑穗菌驅動蛋白 (Ustilago maydis kinesin, Accession Number = AAL87137) [8]、鞭毛藻叢赤殼菌驅動蛋白 (Nectria haematococca kinesin, Accession Number = AAB47851) [9]、有絲真菌驅動蛋白 (Syncephalastrum racemosum kinesin, Accession Number = CAA12647) [10]、團藻驅動蛋白 (Volvox carteri f. nagariensis kinesin, Accession Number = EFJ44391) [11]、長囊水雲驅動蛋白 (Ectocarpus siliculosus kinesin, Accession Number = CBJ32550) [12]、串珠鐮刀菌驅動蛋白 (Fusarium verticillioides kinesin, Accession Number = AAO59304) [7]、蒺藜苜蓿驅動蛋白 (Medicago truncatula Kinesin, Accession Number = AES82508) [13]，然後利用Clustal X (序列比對軟體) 將這十三種驅動蛋白的蛋白質序列進比對 [14,15]，比對後的結果使用Mega (演化分析軟體) 進行序列之間的演化樹重建 [16,17]，而這十三種驅動蛋白的氨基酸序列如表1所示 [18]，比對之後的結果如表2所示。

三、結論

在Clustal X 的分析中比對了這十三種驅動蛋白的氨基酸序列，由表2的結果可以觀察這十三種驅動蛋白的氨基酸序列之間相同與相異之處。在Mega的分析中重建了這十三種驅動蛋白的演化樹，而驅動蛋白演化樹如圖2所示，由圖2的演化樹重建結果可以得知「粉色麵包黴菌驅動蛋白和鞭毛藻叢赤殼菌驅動蛋白」、「串珠鐮刀菌驅動蛋白和長囊水雲驅動蛋白」、「玉米小斑病菌驅動蛋白和玉米黑穗菌驅動蛋白」、「熱帶家蚊驅動蛋白和埃及斑蚊驅動蛋白」這四組的親緣關係是最為相近的。由此可知，在本文中利用生物分子演化軟體，將可以瞭解並有效的建立驅動蛋白的演化模式。

四、致謝

最後非常感謝在求學的過程中一直支持我的家人。

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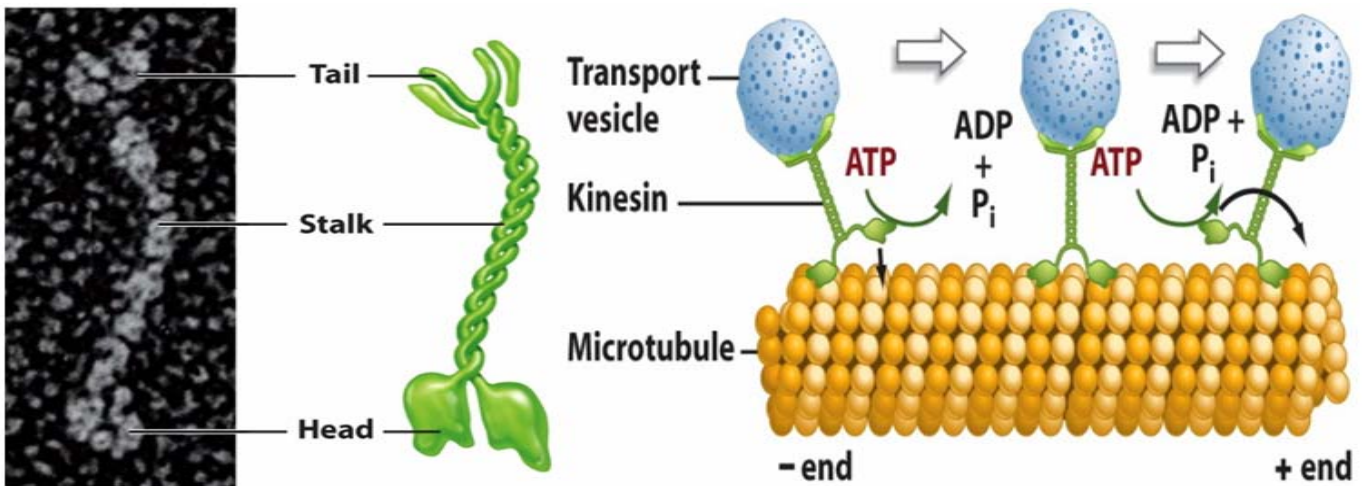


圖1. 驅動蛋白的基本結構圖與行走機制

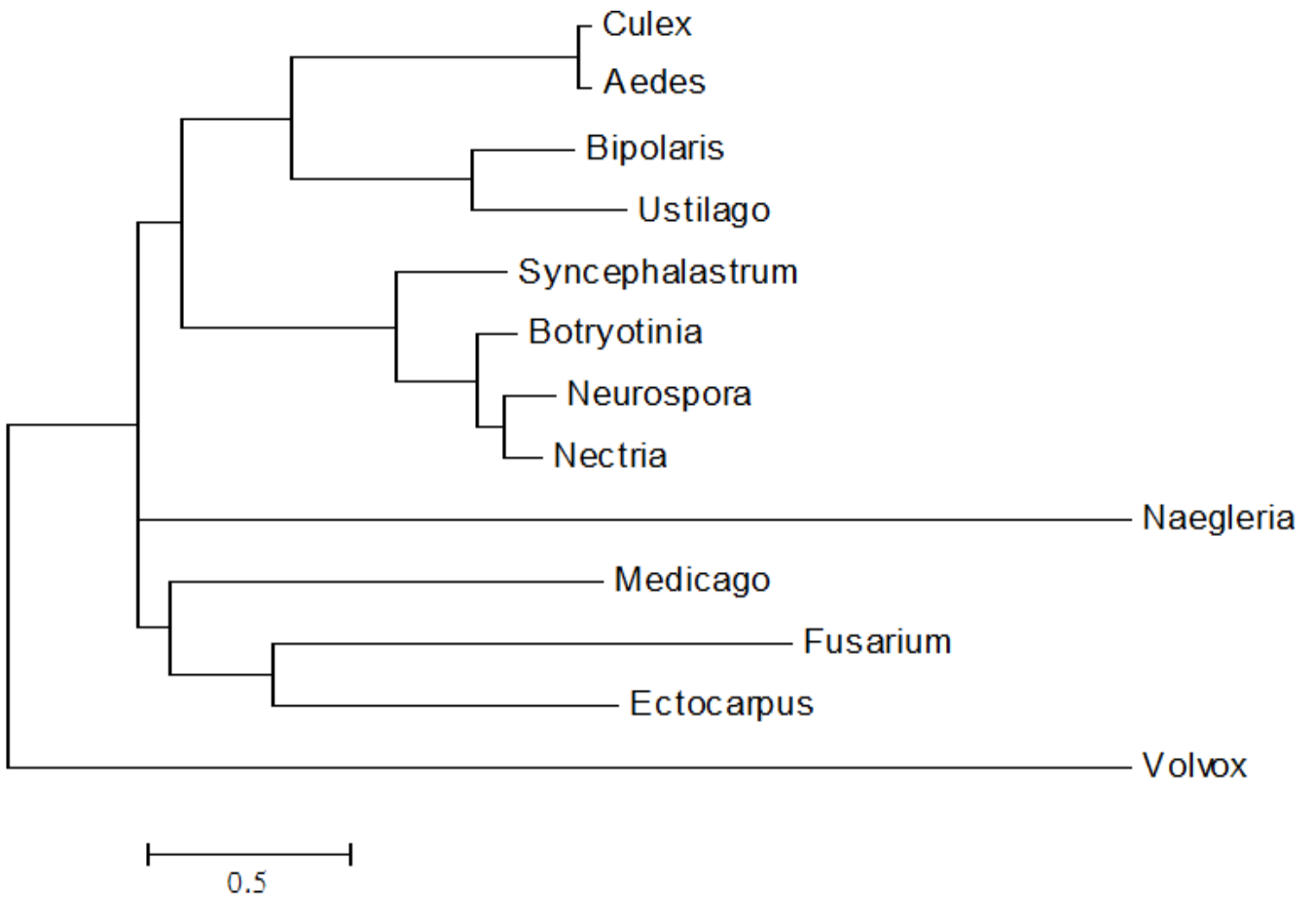


圖2. 驅動蛋白演化樹

表1. 驅動蛋白氨基酸序列

| Culex quinquefasciatus kinesin | | | | | |
|--------------------------------|-------------|------------|------------|------------|------------------------|
| 1 | MSDKIKVAVR | VRPFNRRELE | LATENVIEMN | DSQTILKYPA | TLDKMERKPP KMFAFDHCFY |
| 61 | STDPVAENFA | SQELVFKDVG | RDILDNAFQG | YNACIFAYGQ | TGSGKSYTMM GNQENKGIIP |
| 121 | RLCDELFAFI | AAKQTDELNY | KVEVSYMEIY | NEKVHDLDDP | KTSKQSLKVR EHNVLGPYVD |
| 181 | GLSQLAVTSF | MDIDNLMAEG | NKSRTVAATN | MNSESSRSHA | VFTVVLTQTL IDTLSGVTGE |
| 241 | KVSRVSLVDL | AGSERAVKTG | AVGERLKEGS | NINKSLTTLG | LVI SKLADQT SGSKNKDKFV |
| 301 | PYRDSVLTWL | LKDNLGGNSK | TVMLATLSPA | ADNYEETLST | LRYADRAKRI VNHAVVNEDP |
| 361 | NARI IRELRM | EVETLREMLK | HATGTSLPGE | MKRVDIHDKL | AESENLMKQI SQTWEEKLEK |
| 421 | TEQIQSERQQ | ALEKMGISVQ | DSGIKVEKNK | YYLVNLNADP | SLNELLVYYL KEVTLIGGHN |
| 481 | NEGTTKQLPD | IQLMGLGIQP | EHCLITIEDG | ELFMAPIDSA | RCCVNGSVAT EKTSLNHGDR |
| 541 | ILWGNHFFFR | VNCPKSNNNN | NNLSSEPQTP | AQHLDYYYAQ | EELMQNEFSN NPIQAAISRL |
| 601 | EKQHEEDKQV | ALEKQRQEYE | KQFQQLRNIL | SPTTPYAPYA | PFDPFRLGKL PPNTPNACLQR |
| 661 | VEKWAQERDE | MFKRSLGQLK | TDIVRANSLV | QEANVLAEM | NKQTKFSVTL QIPPANLSPN |
| 721 | RKRGAFFVSEP | AILVRRMNSG | SQIWSMEKLE | NKMIDMRDMY | QEYKDNNYTV TDENKNKSDP |
| 781 | FYESQENHNL | IGVANIFLEV | LFHDVKLDYH | TPIISQQGEV | AGRLQVEISR VAGQFPQDRV |
| 841 | NESASESSQD | SHEDDDMCEP | ASNQVTCRIS | VKQASGLPLY | LSNFVFCQYS FWNHEVAVVP |
| 901 | ATNQEVAAHN | QNITFKFDHE | SDYIITVNEE | FLEHCSDGAL | SIEVWGHRVS GFSRAKDWEV |
| 961 | EQQAKARSL | ADRWAELSRK | IELWVEIHEL | NDNGDWAPVD | VQCSKDMLTG GVYQLRQGFQ |
| 1021 | RRIMVRVKPV | QNSGTLPIIC | QSIINVSVC | VTVRSKLQKP | MDSYQEEDLT VLRDKWSEAL |
| 1081 | GRRRQYLDQQ | IQKLINKDDK | TEQEKEREQS | LVNQWVSLTE | ERNAVLVPAP GSGIPGAPAS |
| 1141 | WDPPMGMEPH | VPVFLDLNA | DDLTTQSVND | EVPLAGLNSI | LPKEHGKFKY NLQIIQHLDK |
| 1201 | DICAVCSWDS | SIHDSPSLNR | MTEANERVYL | ILKTTVRLSH | PAPMDLVLRK RLALNIYKRQ |
| 1261 | SFTDRLKKLR | IGRAECSSLQ | SGVTYEVVSN | IPKASEELED | RESLAQIAAT GEDVSASDGE |
| 1321 | TYIEKYTKGV | SAVESILTLD | RLRQSVAVKE | LEQVRGPALS | MRKTASVPNF SQMRFFDASL |
| 1381 | ESLLGIGRSE | SFADLKMGLN | SAQSTRETAT | SRQKLKGTSP | GGGEDSANSS YGLSKYNCLL |
| 1441 | SYNLILMMRF | FDASLESLLG | IGRSESFADL | KMGLNSAQST | RETATSRQKL KGTSPGGGED |
| 1501 | SANYSYGLTS | PAASKLAQRM | TTLHEEPLIK | QICYEEEGED | RFSEPEYAEY EDDYEPKPKP |
| 1561 | TMSKMKSSYT | VESFMDIDKR | PGHAGVGGGS | DLCKFSAAGK | GVKPSGGGQV AQVKSQNIAA |
| 1621 | GTPSMSSSTS | SGYGSQAVSC | SNLTNDDTYS | IRSLSVGETP | ETMSPSNNVL RSNNPLMKDV |
| 1681 | VSFDELNGNR | GGDLLEQEAL | AYNSNAKRAS | EPAVMTGSRD | TMIDEDEGEV VNEQEVEEDE |
| 1741 | EVIAMDESHV | SSTADDDSHL | QHEDVVDEEN | NSSKLLQDSD | VMENSFSTPS KHENIPDWVV |
| 1801 | VGESVQIRPY | NTSGVISFVG | GTHFQGGTWI | GVELDTPTGK | NDGTVQGIQY FSCRPKHGIF |
| 1861 | VRVDKILDK | RGRAMRELKR | AEKMKAEFGG | QKSGGQKAVS | ANGPRK |
| Naegleria gruberi kinesin | | | | | |
| 1 | MKPLSVYIQA | FDWNDYSDDI | NMGIKEGKIM | RDFNTWPTTE | YFPDGVFEDP VDCSELFNVA |
| 61 | VKPIVEQAML | GFDGTVLLFE | DEAHRKTLMR | HEKGLIFHTF | EKLFEMIEGK HDQVTIYASS |

121 LMLCNQLFYD VLDSTTPRVK FKELPNKTLK FEGLKRVVPL SMKVVNELVN AGMKHSTLFA
 181 TQHGSTNTRH AVYYMI IEIE QREWKEEDKS FQILKSEIKF VDIMNYFLET SKLGLEMAKT
 241 YDQFLSVVNR LTTGEKFIPIY RDNVLTHSLR EGLGGSNTS IVFSIGTTKQ QILKTIQIAS
 301 SFSKIVNHPK KHIATESQAV VVLHVYDGNQ LTDMEIKDNK GKCIVDLKNN REYQYDGVVE
 361 EMMGNTHDDM NGMIQQSFEH LFSQKSSVS LKASCLCLTG ERFHDILSAN FPVIKFSNE
 421 EPILHGYSKI SLFNLKDSLE FLERCLFNTS CFYNQKETS FTMSNYILIE VDRRIMDENE
 481 KKEHIIHKSQK KFI RMVNYQC EELTCVFKQL KPIARSLDLC QQPIIPLKGC SFVKSLKGF
 541 FGESNMVSIV SCNPNSVQEC IQFATILSKI VNYPTQNIKG SCFSLVANGT ESLMNGTIDD
 601 EKPIELSKFV PKGVISFNKH NMLSYSTQNK IFVVDPNEPS KVEKIPSNHL YDEVRLNWQ
 661 LSQGVGMLLS HDRYNTITLW KCVNQCVDY HLRKTFYCEN VLCKKWDNV ITYLNNTTI
 721 NNDSPPEAR YTRKYSSIVN LPSGTRSFIA ITSHGEVLFY FYDHSKYKVV TSSIQLNLNG
 781 LICADFTILE DGNICVICSE RDSSTIHVAK LAIERGRNVD TTLPNNLILI SRTCFSIDGL
 841 VAGLYLIPYK NKIMIQTQDN KYMIYHQYK RMLSKAVMTS AGDQSLQFKD SKDSKDDITH
 901 ALKYWREDKH FTPLKAEMLS FKTSIDGNL LFTDTTKVHV YKYAAEIMSF KHYQTIDTKG
 961 ETDELILEEP INNPLPKKRK LTEEPVDTTI CDADISPNC VIAVLDSSMK VRLFPLQKRS
 1021 NAEYINMLNL CLINNYDRWD LFASIKKLV PEEITTIGAE FEQCRLKEN SSKNVIYIYS
 1081 LEMFIFSIYL

Aedes aegypti kinesin

1 KPPKIFAFDH CFYSTDPDAD NFASQELVFA NMGRDILDNA FQGYNACIFA YGQTGSGKSY
 61 TMMGNQENKG IIPRLCDEL FGSIAAKQTEE LTYKVEVSYM EIYNEKVHDL LDPKTSKQSL
 121 KVREHNVLGP YVDGLSQLAV TSFMDIDNLM AEGNKSRTVA ATNMNSESSR SHAVFTVVL
 181 QTLIDTLGSV TGEKVSRSVSL VDLASERAV KTGAVGERLK EGSNINKSLT TLGLVISKLA
 241 DQASGNRNKD KFVPYRDSVL TWLLKDNLGG NSKTVMVATL SPAADNYEET LSTLRYADRA
 301 KRIVNHAVVN EDPNARI IRE LRKEVETLRE MLKHATGASI GDMKRGD IHD KLAESNLMK
 361 QISQTWEEKL EKTEQIQSER QQALEKMGIS VQDSGKVEK NKYYLVNLNA DPSLNELLVY
 421 YLKDVTLIGG RSNDVNKQPD IQLLGLGIQP EHCLITIEDG ELFMPIENA RCCVNGSVVT
 481 DKTSLNHGDR ILWGNHFFR VNCPKSNNNN NLSSEPQTP AQHLDYYYAQ EELMQNEFSN
 541 NPIQAAISRL EKQHEEDKQV ALEKQRQEYE KQFQQLRNIL SPTTPYAPYA PYDPFRLGKL
 601 PPNTPNALQR VEKWAQERDE MFKRSLGQLK TDIVRANSLV QEANVLA EEM DKQTKFSVTL
 661 QIPPANLSPN RKRGA FVSEP AILVRRMNSG SQIWSMEKLE NKLIDMRD WY QEFKDNNTL
 721 MDENKNKSDP FYESQENHNL IGVANIFLEV LFHDVKLDYH TPIISQQGEV AGR LQVEISR
 781 VAGQFPQDRI NESASESSQD SHEDDDMCDP PSNQVTCRIS IKQASGLPLY LSNFVFCQYS
 841 FWNHDVAVVP ATNQEVA AHN QNITFKFDHE NDFNVTVNEE FLEHCTD GAL SIEVWGHRSV
 901 GFSRAKDWEV EQQAKARSL ADRWAELSRK IELWVEIHEL NDNGDWAPVD VQCSKMLT G
 961 G VYQLRQGFQ RRVLVRVKPV QNSGTLPIIC QSIINVSVC VTVRSKLQKP MDSYQ EEDLT
 1021 VLRDKWSEAL GRRRQYLDQQ IQKLINKDDK TEQEKEREQS LVNQVWVSLTE ERNAVLPVAP
 1081 GSGIPGAPAS WDPPLGMEPH VPVFLDLNA DDLTTQSVND EVPIAGINSI LPKEHGKNFY
 1141 NLQIIQH QDK DICACCSWDS SIHDS PALNR MTEANERVYL ILKTTVRLSH PAPMDLVLRK

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|------|------------|------------|------------|------------|------------|------------|
| 1201 | RLALNIYKRQ | SFTDRLKKLR | IGRAESSSLQ | SGVTYEVVSN | IPKASEELED | RESLAQIAAT |
| 1261 | GEDVSASDGE | TYIEKYTKGV | SAVESILTLD | RLRQSVAVKE | LEQVRGPTLS | MRKTASVPNF |
| 1321 | SQVQYYPRKI | PRFFDASLES | LLGIGRSESF | ADLKMGLNSG | KCILLDTEPC | VLKFKLKNTT |
| 1381 | TGSSDESPNS | SYGAASPAAS | KLAQRMTTLH | EEPLIKQICY | EEEGEDRFSE | PEYADYDFYE |
| 1441 | PAKKPNLSKM | KSSYTVESFI | DIDKRPTND | LGGKYGGSAM | AKVKSQNIAA | GTPSMSSTS |
| 1501 | SGYGSQAVSC | SNLTNDDSYS | IRSLVGETP | GYTDENDQEI | SELDSPFSPF | AETMSPAISS |
| 1561 | EFPKRVNPFL | KDVANFDQLN | GNQGEEYDDE | RATELHQMYN | NNLKRASEPA | ILSSSSASEM |
| 1621 | INEEDEGVDE | QGGDVEEDEE | EETTRTIEEV | GEEQMQQEE | CNMNETVDEE | NNSSKLMNDS |
| 1681 | DVMESSFTTP | SKHENIPEWV | VVGESVQIRP | YNTSGVIAFV | GGTHFQGGTW | IGVELDTPTG |
| 1741 | KNDGTVQGIQ | YFNCKQKHGI | FVRVDKILD | KRGRAIRELK | RAEKMKGW | |

Neurospora crassa kinesin

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|-----|------------|------------|------------|------------|------------|------------|
| 1 | MSSSANSIKV | VARFRPQNRV | EIESGGQPIV | TFQGPDTCTV | DSKEAQSFT | FDRVFDMSCK |
| 61 | QSDIFDFSIK | PTVDDILNGY | NGTVFAYGQT | GAGKSYTMMG | TSIDDPDGRG | VIPRIVEQIF |
| 121 | TSILSSAANI | EYTVRVSYME | IYMERIRDLL | APQNDNLPVH | EEKNRGVYVK | GLLEIYVSSV |
| 181 | QEVYEVMRRG | GNARAVAATN | MNQESSRSHS | IFVITITQKN | VETGSAKSGQ | LFLVDLAGSE |
| 241 | KVGKTGASGQ | TLEEAKKINK | SLSALGMVIN | ALTDGKSSHV | PYRDSKLTRI | LQESLGGNSR |
| 301 | TTLIINCSPS | SYNDAETLST | LRFGMRAKSI | KNKAKVNAEL | SPAELKQMLA | KAKTQITSFE |
| 361 | NYIVNLESEV | QVWRGGETVP | KEKWVPPLEL | AITPSKSAST | TARPSTPSRL | LPESRAETPA |
| 421 | ISDRAGTPSL | PLDKDEREEF | LRRENELQDQ | IAEKESIAAA | AERQLRETKE | ELIALKDHDS |
| 481 | KLKENERLI | SESNEFKMQL | ERLAFENKEA | QITIDGLKDA | NSeltaelDE | VKQQLDMKM |
| 541 | SAKETSAVLD | EKEKKAEM | AKMMAGFDLS | GDVFSDNAER | VADAIQLDA | LFEISSAGDA |
| 601 | IPPEDIKALR | EKLVETQGFV | RQAELESSFA | ASSDAEARKR | AELEARLEAL | QQEHEELLSR |
| 661 | NLTEADKEEV | KALLAKSLSD | KSAVQVELVE | QLKADIALKN | SETEHLKALV | DDLQRRVKAG |
| 721 | GAGVAMANGK | TVQQQLAEFD | VMKKSMLRDL | QNRCERVVEL | EISLDETREQ | YNNVLRSSNN |
| 781 | RAQQKKMAFL | ERNLEQLTQV | QRQLVEQNSA | LKKEVAIAER | KLMARNERIQ | SLESLLQESQ |
| 841 | EKMAQANHKF | EVQLAAVKDR | LEAAKAGSTR | GLGTDAGLGG | FSIGSRIAKP | LRGGGDAVAG |
| 901 | ATATNPTIAT | LQQNPPENKR | SSWFFQKS | | | |

Bipolaris maydis kinesin

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|-----|-------------|------------|------------|------------|------------|------------|
| 1 | MSVASTTSLP | EKQHRPPTH | LRLPHTYTPD | FRLARPLHA | CPPWRPEEAA | TSRSWCDVDP |
| 61 | STGEMKGDQT | ILSPPANTDV | KGKAAKAAAE | GVKTFAFDRS | YWSFDRDAPN | YAGQDNLHED |
| 121 | LGKPLLDNAF | QGYNNCIFAY | GQTGSGKSYS | MMGYGAEYGI | IPKICQDMFE | RIKGMQQDKN |
| 181 | STCTVEVSYL | EIYNERVRDL | LNPSNKGCLR | VREHPSTGPY | VEDLAKLVVQ | SFSEIENLMD |
| 241 | EGNKARTVAA | TNMNETSSRS | HAVFTLTLTQ | KRHDVETSMS | GERVAKISLV | DLAGSERAQS |
| 301 | TGATGARLKE | GAEINRSLST | LGRVIAALAD | QSSGKKAQV | PYRDSILTWL | LKDSLGGNSM |
| 361 | TAMIAAISPA | DINFEETLST | LRYSADAKRI | KNHAVVNEDP | NARMIRELKE | ELSKLRSQLG |
| 421 | GGGGGGGGAA | GSNGIVEEQY | PPDTPLEKQM | VSITQADGST | KKVSKAEIAE | QLTQSEKLYT |
| 481 | ELNQTWEEKL | QKTEEIHKER | EAALEELGIS | IEKGFVGLST | PKNMPHLVNL | SDDPLLTECL |
| 541 | VYNLKP GTTT | VGNSDVGQT | AQIRLNGSQI | LAEHCNFENV | DGKVTVIPQE | GASVMVNGVR |

601 IDKPRLLKSG HRIILGDFHI FRFNNPQEAR AERAEVGTSL LRQVTAGQL GSSPSPAPRP
661 GHDRSYSSIS VANSDFDPDS PRAGSPALWQ RGRESEFSYA RREALTAWLG PDKRIENLPD
721 EDFEALYEDL SRLRETRKAR PESRMISDEG DTESMSSYPV REKYASGGTL DNFSLDTALT
781 MPSTPHQDGS EKMQEIREEM QNKIDQSRDD FQARLKADED AKVELQELRA AKEAMQRQMK
841 AQKEAFQRHL KELGHDIPL EDEDLEIKSA NAQKEQDAQD AQDERQLELI RSVLKQWRRR
901 KYVTMAETLL QNAAILKEAQ VMSQQMDKRV VFQFCIVDVG HTVPSSYDLV NMGIPGEDDE
961 YLDSQSKPCV GVRVIDFKNE VVHLWSLQKL RDRVRRMHQV HQYMNRP EYF QHFNPEPFS
1021 DPCMPEFTRI GDVDVPLAAV FESRVRDFSL DVISPYTSNP IGIIRLSLEP SSAEAPSTTL
1081 KFNVMHEMV GFSEREGTKV HAVLFVPGIS DESGATTTTW ITDFNESPIR FESVHMSLP
1141 YPSRDTFLR ISIFAKVTDI HLDMLLSWDD MRDSAEPKQ KRRNARLPES EPHYTEDTHDI
1201 FARIQVQEIT DDGTYQPVEV TQSSVMDQGV YQLHQGLARR IVVNLTHTSG ETIQWEGVKS
1261 LRMGHIRMVD AAGNCPNYGS PVKEVPVDLI SPPTVRNNAD GTTNVKFVGR WDSTAHASQI
1321 LDRATKDNFR VRATLLFDVM SSKLIEPMTF SFDLFVQIRG RSYMPTSLF SLTNIWNTVK
1381 IVHSTVGIFS VAIRPTSVKR ATDLWRMNTK DDYIKGEEQL AGWTPRGVSL VRDFINVEKR
1441 RRRVAEIETA RSVLSSKALS IPTSALASSK DKPLDDAQRA LLQRIISLWK TKKAPAEIIL
1501 NSTNLEPTN GAAFAPRSSS PSPSPTSLT ATVRFIPKNP NLMKASYLLT PDPTNTRWTR
1561 RYVELRKPYL HIYSTDGDEI NAINISTARI DHSPQIAKLL GGVQNQHSNS ANSGGAGVY
1621 KDVFVAVFAR SNTYIFRARS EREKIEWILR LDQSYFSSGE GSEESA

Botryotinia fuckeliana kinesin

1 MSNSIKVCR FRPQRIENE QGAQPVVFE ADDTCALDSN GAAGSFTFDR VFGMSSRQKD
61 IFDFSIKPTV DDILNGYNGT VFAYGQTGAG KSYTMMGTNL DNDDGRGVIP RIVEQIFASI
121 LSSPGTIEYT VRSYMEIYM ERIRDLLQPQ NDNLPHEEK NRGVYVKGLL EYVSSVQEV
181 YEVLRGGDA RVVASTNMNA ESSRSHSIFV ITITQKNVET GSAKSGQLFL VDLAGSEKVG
241 KTGASGQTL EAKKINKSLS ALGMVINNLT DGKSSHIPYR DSKLTRILQE SLGGNSRTTL
301 IINCSPSSYN AEETLSTLRF GMRAKAIKNK AKVNAELSPA ELKALLRKAQ SQVTTFETYV
361 STLEGEVQLW RKGESVPKEQ WAPPLAGVSG AKAAAAQTPR PSTPSRLATE SRAETPVAER
421 SATPGIPIDK DEREFLRRE NELQDQITEK ETQIAAAEKT LRDTKEELTY LKERDTKVNK
481 DNEKLTSEAN EFKMQLERLA FESKEAQITM DSLKEANAEL TAELDELKQQ LLNVKMSAKE
541 STAALDEKEK RKAEKMAQMM AGFDLGGDVF SENEATIKKV IDHIDSLHEQ SSAGEAIPPD
601 EFEELKAKLV ETQGIVRQAE LSMFGSSSND ANVKRREELE QRLQVLEQEY EDLLERNLGE
661 GDVAEIKERL EKAYSNNQDI KVELVEDLKK EVAQKSAEIE KFKAVNEDLQ QRVKSGSASN
721 GTAPGSASGK TVQQQIAEFD VMKSLMRDL QNRCERVVEL EISLDETREQ YNNVLRSSNN
781 RAQQKKMAFL ERNLEQLTHV QRQLVEQNGS LKKEVAIAER KLIARNERI Q SLESLLQDSQ
841 EKLTASHRY GFPLYFRIDF NHTSIALTF PLDSKPNCQQ

Ustilago maydis kinesin

1 MADSGNIKVV VRCRPMNSRE RNRGASNLIE FVDQHLILS PPNEADTKEN SKATKKKSMP
61 FSFDRAYDEH TEQDDLQFYI GVELLQHAFN GFNTCVFAYG QTGSGKSHSM VGYAQAKGII
121 PLTCARLFED INQKTAADPN LKISVEVSYI EIYNEKVRDL LNPKNKGNLK VREHPSLGPY

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|------|------------|-------------|-------------|-------------|------------|-------------|
| 181 | VEDLSKLVVA | SYPDIMNLM | EGNKARTVAA | TNMNETSSRS | HAVFTLVLTQ | KRFDVQTKLE |
| 241 | AEKVSRI | DLAGSERANS | TGATGARLKE | GANINRSLTT | LGKVIAALAI | ASSAVEPVKG |
| 301 | AKKPKTASLD | SFVPYRDSVL | TWLLKDSLGG | NSKTAMIAAI | SPADYEETLS | TLRYADQAKK |
| 361 | IKNKAVVNED | PNAKLIRELK | EELLLRTRV | SGGGGADGES | NWDPSIPPK | QVVRYQTKTG |
| 421 | EIKTVTKAEL | QEQLQSEKI | MSSLNESWEE | KLTKTQEIQK | EREKALEELG | ISVDKGNVGV |
| 481 | HTPKKLPHLV | NLNEDPLMSE | CLIQIKPGH | TLVGNLDSGP | DVHIKLSGTK | ILNKHCMFDH |
| 541 | QDGLVTVTAM | PDSMTMVNGK | RLAPDEPKRL | RSGYRVILGD | FHVFRFNHPE | EVRKARDRVR |
| 601 | STLALSTGEA | HNETLIDGDL | PSTRPDPSPAS | GDVDWTYARR | EYTMALNGQ | NVNFNLDNEE |
| 661 | DLEKLFEDIS | RARSKKSMGS | VLGRPESRAS | LFDDNASESA | SSVIRPYSHG | ALTDSDTSIDP |
| 721 | WSQAGSEMGS | MRFSAGTPIK | ENAYTGAGAS | SPALVAASHR | ETESLRAKVR | EYEEKLTRMA |
| 781 | NGSPRLADEP | IEYSDTQKAL | LKVLVKWKA | HTKVSMAEDA | LCKAVLVKEA | NVISKELAKR |
| 841 | VTYQYTI | FPLAVPTSGV | EAIAGLTFED | DVSDPDLASC | AKPCMGIKVL | DYLHSTCYVW |
| 901 | SMPKFEQRLQ | KMRNLYTFVD | KPEYSKHLNW | SDPFYEAPHP | TYAFVASTLV | PLTPLSRQLS |
| 961 | AKYRLPLHDR | HTAKQIGWCS | VSVKFSVLSL | VPVSARAGGT | ALPAPSGSRN | PSSPTSSSCT |
| 1021 | NGIVNPLVGQ | KLGFQILVDA | ISGISSDDFA | SIHLQVKLSS | FAGNELGKDE | IYTSIPVDLV |
| 1081 | NQESLAEVRL | RRTLSFVLTP | ETIQWLRTGA | APIEVYAKLR | PHYLVALEQH | DSARESEGQQ |
| 1141 | HAAAFVPLHD | DSRSLTAGQQ | KTMSNTIKER | LESENEMRNEE | RHFILASVQI | CELDASGEYM |
| 1201 | PVPVRASSAL | DPGSFFLRQG | LQRKLVQLA | HDSGRQFLWS | RVTKLELADV | RLLDSRGRVH |
| 1261 | GGKASDAVQL | KTPLKQSQVE | FANNGTSQLE | LWAWWDSSVH | DSLHLNRTTS | AGHRVLIRLS |
| 1321 | FEIQVDRCSA | PAAFSMDLAV | SINGRDAKPP | GRLMSFIEGS | TSMTKTSIF | EVRLVPPMMK |
| 1381 | RPCELWRLDT | GSKYVRGQEM | LGGWKARGVS | LVGDHAALVQ | RERRRAEVEG | VRATLKGRSA |
| 1441 | MMRNVDANA | ESKEELAAARV | VAVWQRAVRD | SKVGVVIGVQ | PSTNAASAGG | TTCKTGADGL |
| 1501 | VGMFAAPSAV | DGTNGLGIDN | LSASSPAKI | ERTRSTWSST | APAPAPAPSA | PAAPAALTAI |
| 1561 | VALLPRTATT | SHRGLWIPL | ETITDTWVRR | FLVLRPFLH | IYESNAQVDE | VMVINVEAVR |
| 1621 | VEYDENTERL | LGKQNVFAVY | TANNSYFFQA | DSDKDRQVWM | KLLDGSYNGD | AGHVFC |

Nectria haematococca kinesin

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|-----|------------|------------|------------|------------|------------|-------------|
| 1 | MSSANSIKVV | ARFRPQNKVE | LASGGMPIVS | FDGEDTCSLD | SKEAQSFTF | DRVFDMACKQ |
| 61 | QDIFDFSIRS | TVDDILNGYN | GTVFAYGQTG | AGKSYTMMGT | NIDDDDGGRV | IPRIVEQIFA |
| 121 | SIMSSPGTIE | YTVRVSYMEI | YMERIRDLLA | PQNDNLPVHE | EKNRGVYVKG | LLEIYVSSVQ |
| 181 | EVYEVMRGG | NARAVAATNM | NQESSRSHSI | FVITITQKNV | ETGSAKSGQL | FLVDLAGSEK |
| 241 | VGKTGASGQT | LEEAKKINKS | LSALGMVINA | LTDGKSSHIP | YRDKLTRIL | QESLGGNSRT |
| 301 | TLIINCSPTS | YNDATLSTL | RFGLRAKSIK | NKAKVNAELS | PAELKSLKK | AQGQVTNFES |
| 361 | YISNLEGEIQ | LWRAGESVPK | EKWASPKTTE | AVARTKADAR | SSTRPSTPSL | IAESRSETPA |
| 421 | ISERAGTPSL | PLDKDEREEF | LRRENELQDQ | ISEKESQATA | AEKQLRETKE | ELVYLKEHDS |
| 481 | KVDKENEKLT | TEVNEFKMQL | ERLTFESKEA | QITMDTLKEA | NTELTTELDD | VKQQLLDVKM |
| 541 | SAKETGAALD | EKEKRKAEM | AKMMAGFDLG | GEVFSENERH | IAETIEKVDA | LHELSTATGDN |
| 601 | IAPDEFQALR | ARLVETQGIV | RQAELSMYST | TSSEADSRRR | QELEARLEAV | QQEYEEVLTR |
| 661 | NLGPEDVEEV | KARLENAFAN | RQTAQSQFVD | ELKADITQKA | AENTRMKTLI | DDLQQRVKAG |

721 AAAPMANGKT IQQQIAEFDV MKKSLMRDLQ NRCERVVELE ISLDETREYQ NNVLRSSNNR
781 AQQKKMAFLE RNLEQLTQVQ RQLVEQNSAL KKEVAIAERK LIARNERIQS LESLLQDSQE
841 KMAAANHKFE VQLAAVKERL ELAKAGSTRG LNSPGGFSFA SAGSRIAKPL RGGGGSDVAP
901 AIPTIQNLHQ TEGNSGSSNK RASWFFNKS

Syncephalastrum racemosum kinesin

1 MSGNNIKVVC RFRPQNSLEI REGGTPIIDI DPEGTQLELK GKEFKGNFNF DKVFGMNTAQ
61 KDVFYDIKT IVDDVTAGYN GTVFAYGQTG SGKTFTMMGA DIDDEKTKGI IPRIVEQIFD
121 SIMASPSNLE FTVKVSIMEI YMEKVRDLLN PSSENLPHE DKTKGVYVKG LLEVYVGSTD
181 EYVEVMRRGS NNRVVAYTNM NAESSRSHSI VMFTITQKNV DTGAAKSGKL YLVDLAGSEK
241 VGKTGASGQT LEEAKKINKS LTALGMVINA LTDGKSSHVP YRDSKLTRIL QESLGGNSRT
301 TLIINCSPSS YNEAETLSTL RFGARAKSIK NKAKVNADLS PAELKALLKK VKSEAVTYQT
361 YIAALEGEVN VVRTGGTVPE GKWVTMDKVS KGDFAGLPPA PGFKSPVSDE GSRPATPVPT
421 LEKDEREEFI KRENELMDQI SEKETELTNR EKLLLESLREE MGYKKEQEQS VTKENQQMTS
481 ELSELRLQLQ KVSYESKENA ITVDSLKEAN QDLMAELEEL KKNLSEMRQA HKDATDSDKE
541 KRKAEKMAQM MSGFDPSGIL NDKERQIRNA LSKLDGEQQQ TLTVEDLVSL RRELAESKML
601 VEQHTKTI SD LSADKDAMEA KKIIELEGLG ALEKEYEELL DKTIAEEEEAN MQNADVDNLS
661 ALKTKLEAQY AEKKEVQQKE IDDLKRELDK KQSGHEKLSA AMTDLRAAND QLQAALSEQP
721 FQAPQDNDM TEKEKDIERT RKSMAQQLAD FEVMKKALMR DLQNRCEKVV ELEMLEDTR
781 EQYNNVLRAS NNKAQQKKMA FLERNLEQLT NVQQLVEQN ASLKKEVALA ERKLIARNER
841 IQSLETLNHN AQDKLLNQNK KFEQQLATVR ERLEQARSQK SQNSLAALNF SRIAKPLRGN
901 GAAIDNGSDD GSLPTSPTDK RDKRSSWMPG FMNSR

Volvox carteri f. *nagariensis* kinesin

1 MAGYRSPHVS SDGSSAFGFS LPASNQQQQD QLLKTPVAPV MPAAGPRLRD SFLATLRESW
61 ARLELHAGGG GGAMAAAAAG AAAAAAIVPM RSLDLVTPT RTSTSSSAAA AAAELAAVTA
121 RGQLAGSLGG SGGGGDVVVG GGGGSAADAD GVEPLGSALS AEDLQVGFN FSTHLVVDYS
181 KPTRESPATP GRRWTGKRRG KDDTLIGSTG VEGGDDGTAD HNDNNSNEEE EGEDEEGDDD
241 DDGGSLSVVG SSGMGYD TSA EEQELERRRS SMTGSTAGLR PKPSGGSASD MAHGPA SLP
301 QGGGGAATAA ADGGNGGGGR RPPLPPLRLS GSRGASDGG GASTTAPSL S AQQAPAMQSS
361 QASSGMP SRA AAWSGSVLSK LGLHWGRDRG GDSREGGATS ITRNASAGSL LPFPTFRQSV
421 MGSGQ PAAAA HGSFSDRALE EQLAAGVNLG LTRGDDAGDG SSI SGRYYRY VFDPADVQAE
481 MEVTARV RRA AAEALMEANS KLAEAQAAAA ALQQQVEQAK QLEQELEVLR AERSAAHA AK
541 AALEDEMAAV RRQLEAIKET EASLQAELEN VRSQADIWRS SKGGEPEK LK QENTLLRSQL
601 TNRLSELQSC RSRLSDGETE RQRLLEAEE LRNKIQWLTK INLQLETAAS QLNDARRAAA
661 EWQERFM RER NVRRRLHDQL QQLRGNIRVV CRVRPVQVGQ RDIVSYPLEG LLAVSPDPKR
721 YQEFEFDHVF PPCAGQSVVF DEAVASLVRS VANGSSACVF AYGQTGSGKS YTMQGTSEDP
781 APGGGADNAI PAATPLETGA DSTPAATTPA TAASPITAP ASLGGYSIQV SMCEIYNEAV
841 YDVLAPEVGE EDAMKALEVS TAGPCELPPS QDRIPGRTWR LLTSAEGVEA LLRECARNRA
901 AVAAALGIQS SRSHSVLSVR VEVAEGARTE GVSAVGWLHL VDLAGSERAD KSDVAGQ QSK

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|---|------------|------------|------------|------------|-------------|-------------|
| 961 | EAQIAGRSLS | ALGDVISALQ | RRDPHVPRN | SALTAALQDS | LCGDSEILL | CNIAPEATSA |
| 1021 | SETVSSLNFA | SRAAQLELLA | RRAGSAERID | RMGHTSPVFT | DRPQQEGSCN | GVSRRGSAAAA |
| 1081 | SLTSSPLLPH | PPLPIMNGTA | AKLLAAGIRG | GGLRWLLAYI | RTTVTDGHGH | QRINASPES |
| <i>Ectocarpus siliculosus</i> kinesin | | | | | | |
| 1 | MASSGRGNTS | LASMRKKRRT | IGGFRAHAMG | DSYDHSTTAD | ASANNLSMV | PENQLSCLAG |
| 61 | GDSGSENIIV | AVRVRPLSAT | ELAEGKRSCC | DVLRNTLVI | RKGADPGAYL | RSQKGSANEY |
| 121 | SFDAVFPPDA | GQSEVYEGTA | KPHISELEGG | INVTVFAYGA | TGAGKTHMM | GSERVVGVRA |
| 181 | GDEPTEVSGI | VPQSLVELFR | LLTARANIGS | GQEDEAETWS | VRVGYLQVYN | EQIMDLLSDS |
| 241 | SKPLKINEDP | AKGVVVVAGL | AEMEVSSEE | VLDLLRQNA | NRRTEATGAN | QVSSRSHAVL |
| 301 | QVVVTRTLEN | AVSGNRSVRE | SKLSLIDLAG | SERASATNNR | GEQLRQGANI | NKSLLSLANC |
| 361 | INALAGNRRR | RGGKGPQNVK | YRDSKLTHLL | KASLEGRCRL | VMIANVNPSH | VFFDSSHNTL |
| 421 | KYANRAKNIK | VDPRTTESVR | EASRLTDKE | AKMAKDYQAL | KERNQLMEAQ | LESMRNARGY |
| 481 | IAPEPAGFTD | LFAPNTSSIM | SVASSTPGYT | ERYGGGNGAP | QQQQQQQQQL | TAPAPAAAAA |
| 541 | AAAGGSAKPT | GGGGSGDTGR | TRRSVGRGGE | GAAGGSGGGG | QDNGMLPPP | VPRGGRGGDR |
| 601 | RMSEEGLAST | DEEGMVMVG | SPAGVRLGRG | SLSSSSFSPS | SSSSPGTKRK | RAAAEGGGGE |
| 661 | EEEALKAAAA | AAAAAEREI | RELRTELAAE | KTRVCELEGK | VRELESSMAR | MGAQHDVNME |
| 721 | LIATFRHQKE | TAEAAECER | TTADELLALL | KEKEAEVSQL | RSELDGVGSR | SVGAGAAGSS |
| 781 | VGDDATRTAA | DDGNSACAS | GGGQGAATSG | FGGGSSGFRS | GLMMEGDSSA | FGGTLGQIEE |
| 841 | NAGGGAEDME | LENAVAGSAG | GGVVRQQQHT | TGLSDRGSRD | SISSTSTTL | GGASTAAASA |
| 901 | EVASVIKSNR | RKSSMISRSR | KSMIPAPRSS | GRSASSRLG | DVTNSSSTRL | NDHLGGGGSS |
| 961 | SSGCCNTPCD | ANKKGAVKRA | ASVHSGGGDG | SHEMAAVDFA | TTGDGAAGRS | KASSRRASSR |
| 1021 | TGQTPQRQTV | AGRTRSRVSM | APATLRSVR | | | |
| <i>Fusarium verticillioides</i> kinesin | | | | | | |
| 1 | MSVRVSRIR | PLLEKERECD | IIVRADTADT | GKPNTVVKIP | NPKNEAEFEFS | FAFNGVYDRS |
| 61 | TTQEELFTAE | VAPHVKSFLQ | GFDVTIFAYG | VTGTGKTHM | RGGMKLADRG | VIPRMLSNVF |
| 121 | RRGKKIMKDS | RGETDVQVLL | SYEIEYNDKV | FDLLEPEKR | TPTGLPLRAE | ANGKTIIVVGL |
| 181 | SERACEDLKD | FEKLYIEANN | NRVTAATKLN | AHSSRSHAIL | RVKLIQTTP | MVRESTASAI |
| 241 | DLAGEDNRR | TDNGKERLVE | SAAINKSLFV | LSQCIDAIGR | VLNLSPLRSY | HLDTLSSLNV |
| 301 | SSRAKRIEVR | EIENEIVYKQ | VPRANSGLTG | SNVQRQLRP | LANLTVNHNG | NVAAKAADKA |
| 361 | ADANKPVKAF | SVYTDKSKPA | APVSRPLVSS | NIARRVNQVK | RPSENDAAMR | PSKISRPTAP |
| 421 | ASVTVSAAQI | EAMVEKKVSE | ILAAARVAER | ESQPPPTVQP | EISDAVQRR | EALERRIDSD |
| 481 | EWRRDSDSDG | LRFLLAARQH | KERGEDEIAL | KMYEKALPYF | PGQTKLLNKI | ERLRSRLNGN |
| 541 | APAPSPRRET | PRSERKKRRL | VYDDADGDYE | TAEADVDEEE | FAHRALKAKS | RKLKVKALAT |
| 601 | KSILSGDDEG | PASPRQHL | DIVNSRDLQ | IRSLVGFQAK | KARDLVQDLE | LVNDDEAGGR |
| 661 | IDSLAQLRTV | PGMGSRTVER | AYDGLVV | | | |
| <i>Medicago truncatula</i> Kinesin | | | | | | |
| 1 | MEEDRVIDML | TEKFNRVVIH | CNFNSAPEQL | NETSDSMDEN | TMSTQDGHTL | PVLKKILDLS |
| 61 | SKAQNKKQH | VALSEQVCLA | FESFPGLDFL | KSVQLIGDEY | EILKRKYLEV | SLERRRLNNE |

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121 VIELKGNIRV FCRCRPLNEN EIANGSVSV VNFESNSEEL QVVCSDSSKK QKFDHVF KP
181 EDNQEAVFAQ TKPIVASVLD GHNVCFAYG QTGTGKTFTM EGTPEHRGVN YRTLEELFRV
241 SEERQGTIKY ELLVSMLEVY NEKIKDLLAG NSSEATKKLE VKQAADGTQE VPGLVETHVY
301 GADGVWEILK SGNRVRSVGS TSANELSSRS HCLVRVTVMG ENLINGQRTK SHLWLVDLAG
361 SERVGKTEAE GERLKESQFI NKSLSLGDV IAALASKSAH IPYRNSKLTH ILQSSLGGDC
421 KTLMFVQISP SSVDLTETLC SLNFATRVRG IESGPARKQV DLTELLKYKQ MAEKSKHDEK
481 EARKLQDNLQ SVQMLATRE FMCRNLDQKV RDLENQIVVEE RKTRLKQESR SLVAEKTIKR
541 TLLIPLERPP LRKINDSLPP PPERRPSSCS SSLQKENVV RTNLMTTRRR VSIAARPPAA
601 PSQAQPLQPR RRVSLATLKP ETTSSQLTNG SNDHQPMVRN QRKARYSRLF APLTTSAIET
661 TPTLDKSSSS RFDGSPTQAA DSRMMARHPH PAVIALQRKS LVWSPLKRRG IESSRKASFL
721 PSRPSTQMR

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表2. 驅動蛋白比對結果

| CLUSTAL 2.1 multiple sequence alignment | |
|---|---|
| Culex | ----- |
| Aedes | ----- |
| Bipolaris | ----- |
| Ustilago | ----- |
| Neurospora | ----- |
| Nectria | ----- |
| Botryotinia | ----- |
| Syncephalastrum | ----- |
| Medicago | MEEDRVIDMLTEKFNRFV IHCNFNSAPEQLNETSDSMDENTMSTQDGHTLPVLKKILDLS |
| Volvox | ----- |
| Fusarium | ----- |
| Ectocarpus | ----- |
| Naegleria | ----- |
| | |
| Culex | ----- |
| Aedes | ----- |
| Bipolaris | -----MSVASTTSLPEKQHPRPHTHL |
| Ustilago | ----- |
| Neurospora | ----- |
| Nectria | ----- |
| Botryotinia | ----- |
| Syncephalastrum | ----- |
| Medicago | SKAQNLLKQHVALSEQVCLAFESFPGLDFLKSQVLI GDEYEILKRKYLEVSLERRRLNNE |

| | |
|-----------------|---|
| Volvox | -----MAGYRSPHV |
| Fusarium | ----- |
| Ectocarpus | MASSGRGNTSLASMRKKRRTIGGFRAHAMGDSYDHSTTADASANNLSMVPENQLSCLAG |
| Naegleria | ----- |
| Culex | ---MSDKIKVAVRVRPFNRRELELATENVIEMNDSQTI LKYP----- |
| Aedes | ----- |
| Bipolaris | RLPHTYTPDFRLLARPLHACPPWRPEEAATSRSWCDVDPSTGEMKGDQTI LSPPANTDVK |
| Ustilago | -MADSGNIKVVVRCRPMNSRE--RNRGASNLIEFVDQH-----QLILSPPNEADTK |
| Neurospora | MSSSANSIKVVARFRPQNRVE--IESGGQPIVTFQGP----- |
| Nectria | -MSSANSIKVVARFRPQNKVE--LASGGMPIVSFDGE----- |
| Botryotinia | ---MSNSIKVVCFRFPQNRIE--NEQGAQPVVKFEAD----- |
| Syncephalastrum | --MSGNNIKVVCFRFPQNSLE--IREGGTPIIDIDPEG----- |
| Medicago | VIELKGNIRVFCRCRPLNENE-IANGSAVSVVNFESNS-----E |
| Volvox | SSDGSSAFGFSLPASNQQQQDQLLKTVPVMPAAGPRLRDSFLATLRESWARLELHAGG |
| Fusarium | -----MSVRVVSRI RPLEKERECDIIVRADTADTGKP-----NTVV |
| Ectocarpus | GDSGSENIIVAVRVRPLSATELAEGKRSCCDVLRNTLVIRKG-----ADP |
| Naegleria | -----MKPLSVYIQAFDWNDYSDDINMGIKEGKIMRDFN----- |
| Culex | ATLDKMERKPPKMF AFDHCFYSTDPVAENFASQELVFKDVGRI LDNAFQGYNACIFAYG |
| Aedes | -----KPPKIFAFDHCYSTDPDADNFASQELVFANMGRDI LDNAFQGYNACIFAYG |
| Bipolaris | GKAAKAAAEGVKTF AFDRSYWSFDRDAPNYAGQDNLHEDLGKPLLDNAFQGYNNCIFAYG |
| Ustilago | -ENSKATKKKSMPSFD RAYD-----EHTEQDDL FQYIGVELLQHAFNGFN TCVFAYG |
| Neurospora | DTCTVDSKEA QGSFTFDRVFD-----MSCKQSDIFDFS IKPTVDDILNGYNGTVFAYG |
| Nectria | DTCSLDSKEA QGSFTFDRVFD-----MACKQQDIFDFSIRSTVDDILNGYNGTVFAYG |
| Botryotinia | DTCALDSNGAAGSFTFDRVFG-----MSSRQKDI FDFS IKPTVDDILNGYNGTVFAYG |
| Syncephalastrum | TQLELKGKEFKGNFNFDKVF G-----MNTAQKDVF DYSIKTIVDDVTAGYNGTVFAYG |
| Medicago | ELQVVCSDSSKKQFKFDHVFK-----PEDNQEA VFAQTKPIVASVLDGHNVCIFAYG |
| Volvox | GGGAMAAAAAGAAAAAAVPMRSLDLVTTPTRTSTSSSAAAAAELAAVTARGQLAGSLG |
| Fusarium | KIPNPKNEAE EFSFAFNGVYDR-----STTQEELFTA EVAPHVKSLFQGF DVTIFAYG |
| Ectocarpus | GAYLRSQKGSANEYSF DAVFPP-----DAGQSEVYEGTAKPHI SELLEGINVTVFAYG |
| Naegleria | -----TWPTTEYPFDGVFED-----PVDCSELFNVAVKPIVEQAMLGFDGTVLLFE |
| Culex | QTGSGKSYTMMG-----NQENKGIIPRLCDEL FASIAA-----KQTDELNY |
| Aedes | QTGSGKSYTMMG-----NQENKGIIPRLCDEL FGSIAA-----KQTEELTY |

| | |
|-----------------|--|
| Bipolaris | QTGSGKSYSMMG-----YGAEYGIIPKICQDMFERIKG-M-----QQDKNSTC |
| Ustilago | QTGSGKSHSMVG-----YAQAKGIPLTCARLFEDINQKT-----AADPNLKI |
| Neurospora | QTGAGKSYTMMGTS-----IDDPDGRGVIPRIVEQIFTSILS-----SAANIEY |
| Nectria | QTGAGKSYTMMGTN-----IDDDDGRGVIPRIVEQIFASIMS-----SPGTIEY |
| Botryotinia | QTGAGKSYTMMGTN-----LDNDDGRGVIPRIVEQIFASILS-----SPGTIEY |
| Syncephalastrum | QTGSGKTFTMMGAD-----IDDEKTKGIIPRIVEQIFDSIMA-----SPSNLEF |
| Medicago | QTGTGKTFTMEG-----TPEHRGVNYRTLEELFRVSEE-----RQGTIKY |
| Volvox | GSGGGDVVVGGGG-----GSAADADGVEPLGSALSAEDLQVG-----DF |
| Fusarium | VTGTGKHTMRGG-----MKLADRGVIPRMLSNVFRRGKKIM----KDSRGETDV |
| Ectocarpus | ATGAGKHTMMGSERVVGVVAGDEPTEVSGIVPQSLVELFRLLTARANIGSGQEDEAETW |
| Naegleria | DEAHRKTL-----MRHEKGLIFHTFEKLFEMIEG-----KHDQV |
| | *: |
| Culex | KVEVSYMEIYNEKVHDLDPKTSKQ--SLKVREHNVLG-PYVDGLSQLAVTSFMDIDNLM |
| Aedes | KVEVSYMEIYNEKVHDLDPKTSKQ--SLKVREHNVLG-PYVDGLSQLAVTSFMDIDNLM |
| Bipolaris | TVEVSYLEIYNERVRDLLNPSNKG---NLRVREHPSTG-PYVEDLAKLVVQSFSEIENLM |
| Ustilago | SVEVSYIEIYNEKVRDLLNPKNKG---NLKVREHPSLG-PYVEDLSKLVVASYPDIMNLM |
| Neurospora | TVRVSYMEIYMERIRDLLAPQND----NLPVHEEKNRG-VYVKGLLEIYVSSVQEVYEV |
| Nectria | TVRVSYMEIYMERIRDLLAPQND----NLPVHEEKNRG-VYVKGLLEIYVSSVQEVYEV |
| Botryotinia | TVRVSYMEIYMERIRDLLQPNQND----NLPVHEEKNRG-VYVKGLLEIYVSSVQEVYEV |
| Syncephalastrum | TVKVSMEIYMEKVRDLLNPSSE----NLPVHEEKNRG-VYVKGLLEIYVSSVQEVYEV |
| Medicago | ELLVSMLEVYNEKIKDLLAGNSSEATKKLEVKQAADGT-QEVPGLVETHVYGADGVWEIL |
| Volvox | NFSTHLVVDYSKPTRESPATPGRRWTKRRGKDDTLIGSTGVEGGDDGTADHNDNNSNEE |
| Fusarium | QVLLSYEIEIYNDKVFDLLEPEKRTPTGLPLRAEANGK-TIVVGLSERACEDLKDFEKLY |
| Ectocarpus | SVRVGYLQVYNEQIMDLLSDSSKP----LKINEDPAKGVVVVAGLAEMEVTSSSEVLDLL |
| Naegleria | TIYASSMLCNQLFYDVLDDSTTPR----VKFKELPNKT-LCFEGLKRVVLSMKVVNELV |
| | : |
| Culex | AEGNKSRTVAATNMNSESSRSRSHAVFTVVLQTLIDTL SGVTGEKVS RVSLV DLAGSERAV |
| Aedes | AEGNKSRTVAATNMNSESSRSRSHAVFTVVLQTLIDTL SGVTGEKVS RVSLV DLAGSERAV |
| Bipolaris | DEGNKARTVAATNMNETSSRSRSHAVFTLTLTQKRHDVETSMSGERVAKISLV DLAGSERAQ |
| Ustilago | DEGNKARTVAATNMNETSSRSRSHAVFTLVL TQKRFDVQTKLEAEKVSRI SMVDLAGSERAN |
| Neurospora | RRGGNARAVAATNMNQESSRSHSIFVITITQKNVETGSAKSG----QLFLVDLAGSEKVG |
| Nectria | RRGGNARAVAATNMNQESSRSHSIFVITITQKNVETGSAKSG----QLFLVDLAGSEKVG |
| Botryotinia | KRGGDARVVASTNMNAESSRSHSIFVITITQKNVETGSAKSG----QLFLVDLAGSEKVG |
| Syncephalastrum | RRGSNNRVVAYTNMNAESSRSHSIVMFTITQKNVDTGAAKSG----KLYLVDLAGSEKVG |
| Medicago | KSGNRVRSVGSSTANELSSRSHCLVRVTVMGENLINGQRTKS----HLWLVDLAGSERVG |
| Volvox | EEGEDEEGDDDDGGSLSSVGS SSGMGYD TSAEEQELERRRSS-----MTGSTAGLRPK |

| | |
|-----------------|--|
| Fusarium | IEANNRVTAATKLNHSSRSHAILRVKLIQTTPEMVRESTAS-----AIDLAGEDNR |
| Ectocarpus | RQGNANRRTEATGANQVSSRSHAVLQVVVTRTLENVSGNRSVRESKLSLIDLAGSERAS |
| Naegleria | NAGMKHSTLFATQHGSTNTR-HAVVYMIIEIEQREWKEEDKS-----FQILKSEIKFVD |
| | . . . : |
| Culex | KTGAVGERLKEGSNINKSLTTLGLVISKLADQTS-----SKNKDKFVFPYRDSV |
| Aedes | KTGAVGERLKEGSNINKSLTTLGLVISKLADQAS-----NRNKDKFVFPYRDSV |
| Bipolaris | STGATGARLKEGAEINRSLSTLGRVIAALADQSS-----GKKK-----AQVPYRDSI |
| Ustilago | STGATGARLKEGANINRSLTTLGKVI AALAI ASSAVEPVKGAKKPKTASLDSFVFPYRDSV |
| Neurospora | KTGASGQTL EEAKKINKSLSALGMVINALTDGKS-----SHVPYRDSK |
| Nectria | KTGASGQTL EEAKKINKSLSALGMVINALTDGKS-----SHIPYRDSK |
| Botryotinia | KTGASGQTL EEAKKINKSLSALGMVINNLTDGKS-----SHIPYRDSK |
| Syncephalastrum | KTGASGQTL EEAKKINKSLTALGMVINALTDGKS-----SHVPYRDSK |
| Medicago | KTEAEGERLKESQFINKSLSSLGDVIAALASKSA-----HIPYRNSK |
| Volvox | PSGGSASDMAHGPA PSLPQGGGAATAAADGGNGG-----GRRPPLPLR--L |
| Fusarium | RTDNGKERLVE SAAINKSLFVLSQCIDAIG----- |
| Ectocarpus | ATNNRGEQLRQGANINKSLLSLANALAGNRRR-----RGGKGPVNVKYRDSK |
| Naegleria | IMNYFLETSKLGLEMAKTYDQFLSVVNRLTTGEK-----FIPYRDNV |
| | . . |
| Culex | LTWLLKDNLGGNSKTVMLATLSPAADNYEETLSTLRYADRAKRI VNHAVVNEDPNARI IR |
| Aedes | LTWLLKDNLGGNSKTVMVATLSPAADNYEETLSTLRYADRAKRI VNHAVVNEDPNARI IR |
| Bipolaris | LTWLLKDSLGGNSMTAMIAAISPADINFEETLSTLRYADSAKRIKNHAVVNEDPNARMIR |
| Ustilago | LTWLLKDSLGGNSKTAMIAAISPADY--EETLSTLRYADQAKKIKNKAVVNEDPNAKLIR |
| Neurospora | LTRILQESLGGNSRTTLINCSPSSYNDAETLSTLRFGMRAKSIKNKAKVNAELSP---A |
| Nectria | LTRILQESLGGNSRTTLINCSPSSYNDAETLSTLRFGLRAKSIKNKAKVNAELSP---A |
| Botryotinia | LTRILQESLGGNSRTTLINCSPSSYNAEETLSTLRFGMRAKAIKNKAKVNAELSP---A |
| Syncephalastrum | LTRILQESLGGNSRTTLINCSPSSYNAEETLSTLRFGARAKSIKNKAKVNADLSP---A |
| Medicago | LTHILQSSLGGDCKTLMFVQISPSSVDLTETLCSLNFATRVRGIESGPARKQ-----V |
| Volvox | LSGSRGASDGGGASTTAPSLSAQQAPAMQQSQASSGMP SRAAAWSGSVLSKLG LHWGRDR |
| Fusarium | -----RVLNLSPLRSYHLDTLSSLNVSSRAKRIEVR----- |
| Ectocarpus | LTHLLKASLEGRCRLVMIANVNPSHVFFDDSHNTLKYANRAKNIKVDPRTTESVREASRL |
| Naegleria | LTHSLREGLGGNSNTSIVFSIGTTKQKILKTIQIASSFSKIVNHPPKKHIATESQAVVVLH |
| | . : |
| Culex | ELRMEVETLREMLKHATGTS L PGEMKRVDI HDKLA ESENLMKQISQTWEEKLEKTEQIQS |
| Aedes | ELRKEVETLREMLKHATGASIG-DMKRGDI HDKLA ESENLMKQISQTWEEKLEKTEQIQS |
| Bipolaris | ELKEELSKLRSQ LGGGGGGGG-----AAGSNGIVEEQYPPDTPLEKQMV S |

| | |
|-----------------|--|
| Ustilago | ELKEELELLRTRVSGGGGADG-----ESNWDPSIPPDQVVR |
| Neurospora | ELKQMLAKAKTQITS-----FENYIVNLESEVQVWR |
| Nectria | ELKSLLKKAQGQVTN-----FESYISNLEGEIQLWR |
| Botryotinia | ELKALLRKAQSQVTT-----FETYVSTLEGEVQLWR |
| Syncephalastrum | ELKALLKKVKSEAVT-----YQTYIAALEGEVNVWR |
| Medicago | DLTELLKYKQMAEKS-----KHDEKEARKLQ |
| Volvox | GGDSREGGATSITRNASAG-----SLLPFPTFRQSVMGs |
| Fusarium | EIENEIVYKQVPRAN-----SGLTGSNVQRQ |
| Ectocarpus | LTDKEAKMAKDYQALK-----ERNQLMEAQLESMR |
| Naegleria | VYDGNQLTDMEIKDNK-----GKCIVDLKNNREYQY |
| | |
| Culex | ERQQALEKMGISVQDSGIKVEKNKYLVNLNADPSLNELLVYYLKEVTLIGGHNNEGTTK |
| Aedes | ERQQALEKMGISVQDSGIKVEKNKYLVNLNADPSLNELLVYYLKDVTLIGGRSND--VN |
| Bipolaris | ITQADGSTKKVSKAEIAEQLTQSEKLYTEL-----NQTWEEKLQ |
| Ustilago | YQTKTGEIKTVTKAELQEQLQSEKIMSSL-----NESWEEKLT |
| Neurospora | GGETVPKEKWVPP--LELAITPSKSASTTA-----RPSTPSRLL |
| Nectria | AGESVPKEKWASPKTTEAVARTKADARSST-----RPSTPS-LI |
| Botryotinia | KGESVPKEQWAPP--LAGVSGAKAAAAQTP-----RPSTPSRLA |
| Syncephalastrum | TGGTVPEGKWVTMD---KVSKGDFAGLPP-----APGFKSPVS |
| Medicago | DNLQSVQMRLATR----- |
| Volvox | GQPAAAAHGFSFSDRALEEQLAAGVNLGLTR-----GDDAGDGSS |
| Fusarium | PLRPLANLTVHNGNVAAKAADKAADANKP----- |
| Ectocarpus | NARGYIAPEPAGFTDLFAPNTSSIMSVASS----- |
| Naegleria | DGVVEEMMGNTHDDMNGMIQQSFEHLFSDQKSS-----VSLKASCLC |
| | |
| Culex | QLPDIQLMGLGIQPEHCLITIEDGELFMAPIDSARCCVNGSVATEKTSLNHGDRILWGNH |
| Aedes | KQPDIQLLGLGIQPEHCLITIEDGELFMETIENARCCVNGSVVTDKTSLNHGDRILWGNH |
| Bipolaris | KTEEIHKE-REAALEELGISIEKG----- |
| Ustilago | KTQEIQKE-REKALEELGISVDKG----- |
| Neurospora | PESRAETPAISDRAGTPSLPLDKD----- |
| Nectria | AESRSETPAISERAGTPSLPLDKD----- |
| Botryotinia | TESRAETP-VAERSATPGIPIDKD----- |
| Syncephalastrum | DE-----GSRPATPVPTLEKD----- |
| Medicago | ----- |
| Volvox | ISGRYYRYVFDPADVQAEMEVTAR----- |
| Fusarium | ----- |

| | |
|-----------------|---|
| Ectocarpus | -----TPGYTERYG----- |
| Naegleria | LTGERFHDILSANFPVIKFSNEEP----- |
| Culex | HFFRVNCPKSNNNNNNLSSEPQTPAQHLDYYYAQEELMQNEFSNNPIQAAISRLEKQHEE |
| Aedes | HFFRVNCPKSNNNNNNLSSEPQTPAQHLDYYYAQEELMQNEFSNNPIQAAISRLEKQHEE |
| Bipolaris | -FVGLSTPKNMPHLVNLSDDP-----LLTECLVYNLKP GTTTVGNSDVD |
| Ustilago | -NVGVHTPKKLP HL VNLNEDP-----LMSECL IYQ IKPGHTLVGNLDS- |
| Neurospora | -EREEFLRRENELQDQIAEKE-----SIAAAAERQLRETKEELIALKD- |
| Nectria | -EREEFLRRENELQDQISEKE-----SQATAAEKQLRETKEELVYLKE- |
| Botryotinia | -EREEFLRRENELQDQITEKE-----TQIAAAEKTLRDTKEELTYLKE- |
| Syncephalastrum | -EREEFIKRENELMDQISEKE-----TEL TNREKLL ESLREEMGYK E- |
| Medicago | -----EFMCRNLQDKVRDLENQIVE |
| Volvox | -----VRRAAAEA-----LMEANSKLAEAQAAAAALQQQV |
| Fusarium | -----VKAFSVYTDKSKPAAPVSRPL |
| Ectocarpus | -----GGNGAPQQQQQQQQQLTAPAPA |
| Naegleria | ILHGYSKISLFNLKDSLEFLER-----CLFNTSCFYNQKETSSTMSNYILI |
| Culex | DKQVALEKQRQEYEQFQQLRNILSPTTPYAPYAPFDPFRLGKLPNTPNAQLRVEKWAQ |
| Aedes | DKQVALEKQRQEYEQFQQLRNILSPTTPYAPYAPYDPFRLGKLPNTPNAQLRVEKWAQ |
| Bipolaris | GQTAQIRLNGSILAEHCNFENVDGKVTVIPQEGASVMVNGVRID-----KPRLLK |
| Ustilago | GPDVHIKLSGTKILNKHCFMDHQDGLVTVTAMPDSMTMVNGKRLAP-----DEPKRLR |
| Neurospora | -HDSKLGKENERLISESNEFKMQLERLAFENKEAQITIDG-----LK |
| Nectria | -HDSKVDKENEKLTTEVNEFKMQLERLTFESKEAQITMDT-----LK |
| Botryotinia | -RDTKVNKDNEKLTSEANEFKMQLERLAFESKEAQITMDS-----LK |
| Syncephalastrum | -QEQSVTKENQQMTSELSELRLQLQVSYESKENAITVDS-----LK |
| Medicago | ERKTRLKQESRSLVAEKTIKR TLLIPLERPP-----LR |
| Volvox | EQAKQLEQELEVLRAERSAHAAKAALEDEMAAVRRQLEA-----IK |
| Fusarium | VSSNIARRVNQVKRPSENDAAMRPSKISRPTAPASVTVSA-----A |
| Ectocarpus | AAAAAAGGSAKPTGGGGSGDTGRTRRSVGRGGEGAAGGSGGG-----GQ |
| Naegleria | EVDRRIMDENEKKEHIHKSQKFI RMVNYQCEELTCVFKQLKP-----IAR |
| Culex | ERDEMFKRSLGQLKTDIVRANSLVQEANVLAEMNKQTKFS-----VTLQI |
| Aedes | ERDEMFKRSLGQLKTDIVRANSLVQEANVLAEMDKQTKFS-----VTLQI |
| Bipolaris | SGHRIILGDFHIFRFNPNQEARAERAIEVGTSLLRQTVTAGQLGSSPSPAPRPGHDRSYSS |
| Ustilago | SGYRVILGDFHVFRFNHPPEVRKARDRVRSTLALS-----TGEAHNETL |

| | |
|-----------------|---|
| Neurospora | DANSELTAELDEVKQQMLDMKMSAKETSAVLDEKEKK-----KAEK |
| Nectria | EANTELTTTELDDVKQQLLDVKMSAKETGAALDEKEKR-----KAEK |
| Botryotinia | EANAELTAELDELKQQLLNKMSAKESTAALDEKEKR-----KAEK |
| Syncephalastrum | EANQDLMAELEELKKNLSEMRQAHKDATDS--DKEKR-----KAEK |
| Medicago | KINDSLPPPPERRPSSCSSSLQGKENVRTNLMTTRR----- |
| Volvox | ETEASLQAELENVRSQADIWRSSKGGEPEKLKQENTLLR-----SQ |
| Fusarium | QIEAMVEKKVSEILAAARVAAERESQPPPTVQPEISDAVQR-----RLEA |
| Ectocarpus | DGNGMLPPPVP--RGGRRGDRRMSEEGLASTDEEGGMVMVG-----SPAGVRL |
| Naegleria | SLDLCQQPIIPLKGCFSVKSLKGDFFGESNMVSI VSCN-----PNS |
| | . |
| Culex | PPANLSPNRKRGAFVSEPA ILVRRMNSGSQ IWSMEKLENKMI DMRDMYQEYKDNNYTVTD |
| Aedes | PPANLSPNRKRGAFVSEPA ILVRRMNSGSQ IWSMEKLENKLI DMRDWYQEFKDNFTLMD |
| Bipolaris | ISVANSDFDPDPRAGSPALWQRGRESEFSYARREALTAWL-GPDKRIENLPDEDFEALY |
| Ustilago | IDGDLPSTRPDSPASG-----DVDWTYARREYTMAKLNGQNVNFDNLNEEDLEKLF |
| Neurospora | MAKMMAGFDLSGDVFS DN-----ERAVADAI AQLDALFEISSAGDAIPPEDIKALR |
| Nectria | MAKMMAGFDLGGEVFS EN-----ERHIAETIEKVDALHEL SATGDNIAPDEFQALR |
| Botryotinia | MAQMMAGFDLGGDVFSEN-----EATIKKVIDHIDSLHEQSSAGEAIPPDEFEELK |
| Syncephalastrum | MAQMMSGFDPSG-ILNDK-----ERQIRNALSKLDGEQQQ-----TLTVEDLVSLR |
| Medicago | -RVSIAARPPAAPSQAQP-----LQPRRRVSLATLKPETTSSQLTNGSNDHQPMV |
| Volvox | LTNRLSELQSCRSLSDG-----ETERQRLREAEELRNKI QWLT KINLQLETAA |
| Fusarium | LERRIDSDEWRDSDKSDG-----LRFLAARQHKERGEDEIALKMYEKALPYFP |
| Ectocarpus | GRGSLSSSSFS PSSSSSP-----GTKRKRAAAEGGGGEEEEALKAAAAAAAAAAE |
| Naegleria | VQECIQFATILSKI VNYP-----TQNIKGSCFSLVANGTESLMNGTIDDEKPIELS |
| Culex | ENKNKSDPFYESQENHNLIGVANIFLEVL FHDVKLDYHTPIISQQGEVAGRLQVEISRVA |
| Aedes | ENKNKSDPFYESQENHNLIGVANIFLEVL FHDVKLDYHTPIISQQGEVAGRLQVEISRVA |
| Bipolaris | EDLSRLRETR-----KARPESRMI SDEGDTE SMSSYPVREKYASGGTLDNFSLDTALTMP |
| Ustilago | EDISRARSKKSMG SVLGRPESRASLFD-DNASESASSVIRPYSHGALTD DTSID----- |
| Neurospora | EKL VET----- |
| Nectria | ARL VET----- |
| Botryotinia | AKL VET----- |
| Syncephalastrum | REL AES----- |
| Medicago | RN----- |
| Volvox | SQLNDAR----- |
| Fusarium | GQT----- |
| Ectocarpus | REIRELR----- |

| | |
|-----------------|---|
| Naegleria | KFVPKGVISFN----- |
| Culex | GQFPQDRVNESASESSQDSHEDDDMCEPASNQVTCRISVKQASGLPLYLSNFVFCQYSFW |
| Aedes | GQFPQDRINESASESSQDSHEDDDMCDPPSNQVTCRISIKQASGLPLYLSNFVFCQYSFW |
| Bipolaris | STPHQDGSEKMQEIREEMQNKIDQSRDDFQARLKADEDAKVELQELRAAK----- |
| Ustilago | --PWSQAGSEMGS MRFSAGTPIKEN-----AYTGAGASSPALVAAS----- |
| Neurospora | -----QGFVRQAELSSFSA----- |
| Nectria | -----QGI VRQAELSMYST----- |
| Botryotinia | -----QGI VRQAELSMFGS----- |
| Syncephalastrum | -----KMLVEQHTKTI SDL----- |
| Medicago | ----- |
| Volvox | -----RAAAEWQERFM RER----- |
| Fusarium | ----- |
| Ectocarpus | ----- |
| Naegleria | -----KHNMLSYSTQNKIFV VDP----- |
| Culex | NHEVAVVPATNQEVAAHNQNI TFKFDHESDYIITVNEEFLEHCSDGALSIEVWGHRSVGF |
| Aedes | NHDVAVVPATNQEVAAHNQNI TFKFDHENDFNVTVNEEFLEHCTDGALSIEVWGHRSVGF |
| Bipolaris | EAMQRQMKAKQKEAFQRHLKELGHDIPLEIDEDLEIKSANAQKEQD-AQDAQDERQLELIR |
| Ustilago | HRETESLRAKVREYEEKLTRMANGSPRLADEPIEYS-----DTQKALLR |
| Neurospora | ASS-DAEARKRAELEARLEALQQEHEELLSRNLTEADK-----EEVKALLAKSL |
| Nectria | TSS-EADSRRRQLEARLEAVQQEYEEVLRNLGPEDV-----EEVKARLENAF |
| Botryotinia | SSN-DANVKRREELEQRLQVLEQEYEDLLERNLGEADV-----AEIKERLEKAY |
| Syncephalastrum | SADKDAMEAKKIELEGRLGALEKEYEELLDKTI AEEEEANMQNADV-DNLSALKTKLEAQY |
| Medicago | -----QRKARYSRLFAPLTTSAIETTPTL DK-----SSSSR |
| Volvox | -NVRRLHDQLQLRGNIRVVCVRVPVQVQGRDIVSYP-----LEGLLAVSP |
| Fusarium | -----KLLNKIERLSRLNGNAPAPSPRRET PRSERKK-----RRLVYD |
| Ectocarpus | -TELA AEKTRVCELEGKVRELESSMARMGAQHVDNMELIAT-----FRHQKETA |
| Naegleria | NEPSKVEKIPSNHLYDEV RGLNWQLSQGVGMLLSH DRYNTITLWKCVNQCVNDYHLRKT F |
| Culex | SRAKDWEVEQQAKARSLADRWAELSRKIELWVEIHELNDNGDWAPVDVQCSKDMLTGGV |
| Aedes | SRAKDWEVEQQAKARSLADRWAELSRKIELWVEIHELNDNGDWAPVDVQCSKDMLTGGV |
| Bipolaris | SVLKQWRRRKYVTMAETLLQNAAILKEAQVMSQQMDKRVVFQFCIVDVG-HTVPSSYDLV |
| Ustilago | KVLVKWKAHTKVSMAEDALCKAVLVKEANVISKELAKRVTYQYTI VDDFPLAVPTSGVEA |
| Neurospora | SDKSAVQVELVEQLKADIALKNSETEHLKALVDDLQRRVKAGGAGVAMAN----- |

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| Nectria | ANRQTAQSQFVDELKADITQKAAENTRMKTLIDDLQQRVKAG-AAAPMAN----- |
| Botryotinia | SNNQDIKVELVEDLKKEVAQKSAEIEKFKAVNEDLQQRVKSGSASNGTAPGSA----- |
| Syncephalastrum | AEKKEVQQKEIDDLKRELDKQSGHEKLSAAMTDLRAANDQLQAALSEQPFQAPQDNSDM |
| Medicago | FDGSPTQAADSRMMARHPHPIALQRKSLVWSPLKRR----- |
| Volvox | PDKRYQEFDFHVFPFCAGQSVVFDEAVASLVRSVANGSSACVFAYGQTGSGKSYTMQGT |
| Fusarium | DADGDYETAADVDEEEFAHRALKAKSRKLVKALATKS----- |
| Ectocarpus | EEAAECERTTADELLALLKEKEAEVSQLRSELDGVGSRVSVGAGAAGSSVGDDATRTAADD |
| Naegleria | YCENVLCKWCDNVI TYLNDNTTINNDSPELEARYTRKYSSIVNLPSTGRSFIAITS--- |
| | |
| Culex | YQLRQGFQRRIMVRVKPVQNSGTLPIICQSIINVSVCVTVRSKLVKQPMDSYQEEDLTVL |
| Aedes | YQLRQGFQRRVLRVKPVQNSGTLPIICQSIINVSVCVTVRSKLVKQPMDSYQEEDLTVL |
| Bipolaris | NMGIPGEDDE-----YLDSSQKPCVGVVDFKNEVVHLWSLQKLRDRVRRMHQVHQYMN |
| Ustilago | IAGLTEFDDVSDP--DLASCAKPCMGIKVLDYLHSTCYVWSMPKFEQRLQKMRNLYTFVD |
| Neurospora | -----GKTVQQQLAEFDVMKSLMRDLQNRRCERVVELEISLD |
| Nectria | -----GKTIQQQIAEFDVMKSLMRDLQNRRCERVVELEISLD |
| Botryotinia | -----SGKTVQQQIAEFDVMKSLMRDLQNRRCERVVELEISLD |
| Syncephalastrum | TE-----KEKDIERTRKSMAQQLADFEVMKALMRDLQNRCEKVVELEMSLD |
| Medicago | -----GISSRKASFLPS |
| Volvox | SE-----DPAPGGGADNAIPAATPLETGADSTPAATTPATAASPIITAPAS |
| Fusarium | -----ILSGDDEGPA |
| Ectocarpus | GD-----NSACASGGGQGAATSGFGGGSSGFRSGLMMEGDSSAFGG |
| Naegleria | -----HGEVLFYFYDHSKYKWVTSSIQNLNGLICADFTIL |
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| Culex | RDKWSEALGRRRQYLDQQIQKLINKDDKTEQEKEREQSLVNQWVSLTEERNAVLVPAPGS |
| Aedes | RDKWSEALGRRRQYLDQQIQKLINKDDKTEQEKEREQSLVNQWVSLTEERNAVLVPAPGS |
| Bipolaris | RPEYFQHFNPESPFSDPCMEFTRIGDVDVPLAAVFESRVRDFSLDVI SPYTSNPIG--- |
| Ustilago | KPEYSKHLNWSDFYEAPHPTYAFVASTLVPLTPLSRQLSAKYRLPLHDRHTAKQIGWCS |
| Neurospora | ETREQYNNVLRSSNNRAQQKKMAFLERNLEQLTQVQRQLVEQNSA----- |
| Nectria | ETREQYNNVLRSSNNRAQQKKMAFLERNLEQLTQVQRQLVEQNSA----- |
| Botryotinia | ETREQYNNVLRSSNNRAQQKKMAFLERNLEQLTHVQRQLVEQNGS----- |
| Syncephalastrum | ETREQYNNVLRASNNKAQQKKMAFLERNLEQLTNVQKQLVEQNAS----- |
| Medicago | RPSTQMR----- |
| Volvox | LGYSIQVSMCEIYNEAVYDVLAPEVGEEDAMKALEVSTAGPCELP----- |
| Fusarium | SPRTQHLLDIVNSRDLQIRSLVGFAGKARDLV DYLELVNDD----- |
| Ectocarpus | TLGQIEENAGGAEDMELENAVAGSAGGVVRQQHTTGLSDRGRS----- |
| Naegleria | EDGNICVICSERDSSTIHVAKLAIERGRNVDTTLPNNLILISRTCFS----- |

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| Culex | GIPGAPASWDPPMGMEHPVFLDLNADDLTTQSVNDEVPLAGLNSILPKEHGKGFYNL |
| Aedes | GIPGAPASWDPPLGMEHPVFLDLNADDLTTQSVNDEVPIAGINSILPKEHGKGFYNL |
| Bipolaris | ----IIRLSLEPSSAEAPSTTLKFNVMHEMVG-----FSEREGTKVHAVLFVPG |
| Ustilago | VSVKFSVLSPPVVSARAGGTALPAPSGSRNPSSPTSSSCTNGIVNPLVGQKLGQILVDA |
| Neurospora | ----- |
| Nectria | ----- |
| Botryotinia | ----- |
| Syncephalastrum | ----- |
| Medicago | ----- |
| Volvox | ----- |
| Fusarium | ----- |
| Ectocarpus | ----- |
| Naegleria | ----- |

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| Culex | QIIQHLDKIDICAVCSWDSSIHDSPLNRMTEANERVYLILKTTVRLSHPAPMDLVLKRKL |
| Aedes | QIIQHDKIDICACCSWDSSIHDSPLNRMTEANERVYLILKTTVRLSHPAPMDLVLKRKL |
| Bipolaris | IS----DESGATTTWITDFNE-----SPIRFESVHSMSLPYPSRDTF----- |
| Ustilago | ISGISSDDFASIHLQVKLSSFAGNELGKDEIYTSIPVDLVNQESLAEVRLRRTL SFVLTP |
| Neurospora | ----- |
| Nectria | ----- |
| Botryotinia | ----- |
| Syncephalastrum | ----- |
| Medicago | ----- |
| Volvox | ----- |
| Fusarium | ----- |
| Ectocarpus | ----- |
| Naegleria | ----- |

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| Culex | ALNIYKRQSFTDRLKKLRIGRAECSSLQSGVTYEVVSNIPKASEELEDRESLAQIAATGE |
| Aedes | ALNIYKRQSFTDRLKKLRIGRAESSLQSGVTYEVVSNIPKASEELEDRESLAQIAATGE |
| Bipolaris | ----LR----ISIFAKVTDIHLDMLLSWDDMRDS-----AE |
| Ustilago | ETIQWLRTGAAPIEVYAKLRPHYLVALEQHSARESEGQQHAAAFVPLHDDSRSLTAGQQ |
| Neurospora | -----L |
| Nectria | -----L |

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| Botryotinia | -----L |
| Syncephalastrum | -----L |
| Medicago | ----- |
| Volvox | -----PS |
| Fusarium | ----- |
| Ectocarpus | -----DS |
| Naegleria | -----I |
| Culex | DVSASDGETYIEKYTKGVSAVESILTLDRLRQSVAVKELEQVRGPALSMRKTASVPNFSQ |
| Aedes | DVSASDGETYIEKYTKGVSAVESILTLDRLRQSVAVKELEQVRGPTLSMRKTASVPNFSQ |
| Bipolaris | KPKQKRRNARLPESEFYTEDTHDIFARIQVQEI TDDGTYQPVEVTQSSVMDQGVIYQ---- |
| Ustilago | KTMSNTIKERLSENERNEERHFILASVQICELDASGEYMPVVRASSALDPGSFF---- |
| Neurospora | KKEVAIAERKLMARNERIQSLESLLQESQEKMAQANHKFEVQLAAVKDRLEAAKAG---- |
| Nectria | KKEVAIAERKLIARNERIQSLESLLQDSQEKMAAANHKFEVQLAAVKERLELAKAG---- |
| Botryotinia | KKEVAIAERKLIARNERIQSLESLLQDSQEKLTASHRYGFPLYFRIDFNHTSIAL---- |
| Syncephalastrum | KKEVALAERKLIARNERIQSLETLLHNAQDKLLNQNKKEQQLATVRERLEQARSQ---- |
| Medicago | ----- |
| Volvox | QDRIPGRTWRLLTSAEGVEALLRECARNRAAVAAALGIQSSRSHSVLSVRVEVAEG---- |
| Fusarium | -----EAGGRIDSLAQLRTVPGMGSR TVERAYDGLVV----- |
| Ectocarpus | ISSGTSTLGGASTAAASAEVASVIKSNRRKSSMISRSRKS MIPAPRSSGRSASSR---- |
| Naegleria | DGLVAGLYLIPYKNKIMIQTDNKYMIYHQYPKRMSLKAVMTSAGDQSLQFKDSKD---- |
| Culex | MRFFDASLESLLGIGRSESFADLKMGLNSAQSTRETATSRQKLKGTSPGGGEDSANSSYG |
| Aedes | VQYYPRKIP----- |
| Bipolaris | ----- |
| Ustilago | ----- |
| Neurospora | ----- |
| Nectria | ----- |
| Botryotinia | ----- |
| Syncephalastrum | ----- |
| Medicago | ----- |
| Volvox | ----- |
| Fusarium | ----- |
| Ectocarpus | ----- |
| Naegleria | ----- |

Culex LSKYNCLLSYNLILMMRFFDASLESLLGIGRSESFADLKMGLNSAQS---TRETATSRQK
 Aedes -----RFFDASLESLLGIGRSESFADLKMGLNSGKCILLDTEPCVLKFK
 Bipolaris -----LHQGLARRIVVNLTHTSGETIQWEGVKSLRMGHIRMVDAAGNCP
 Ustilago -----LRQGLQRKLVQLAHDSSGRQFLWSRVTKLELADVRLDLSRGRVH
 Neurospora -----STRGLGTDAGLGGFS-----IGSRIAKP
 Nectria -----STRGLNSPGGFSFAS-----AGSRIAKP
 Botryotinia -----LTFPLDSK-----
 Syncephalastrum -----KSQNSLAALNFS-----RIAKP
 Medicago -----
 Volvox -----ARTEGVSAVGWLHLVDLAGSERADKSDVAGQQ----SKEAQIAG
 Fusarium -----
 Ectocarpus -----LLGDVTNSSSTRLN-----D
 Naegleria -----SKDDITHALKYWREDK-----HFTPLKAE

Culex LKGTSPGGGEDSANYSYGLTSPAASKLAQRMTTLHEEPLIKQICYEEEGEDRFSEPEYAE
 Aedes LKNTTTGSSDESPNSSYGAASPAASKLAQRMTTLHEEPLIKQICYEEEGEDRFSEPEYAD
 Bipolaris NYGSPVKEVPVDLISPPTVRNNADGTTNVKVFGRWDSTAHASQILDRATKDNFRVRATLL
 Ustilago GGKASDAVQLKTPLKQQSVEFANNGTSQLELWAWWDSSVHDSLHLNRTTSAGHRVLI RLS
 Neurospora LRGGG-DAVAGATATNPTIATLQQNP-PENKRSSWF--FQKS-----
 Nectria LRGGGGSDVAPAIPTIQNLHQTEGNSGSSNKRASWF--FNKS-----
 Botryotinia -----PNCQQ-----
 Syncephalastrum LRGNG----AAIDNGSDDGSLPTSPTDKRDKRSSWMPGFMNSR-----
 Medicago -----
 Volvox RLSALGDVLSALQRRDPHVPFRNSALTAALQDSL CGDSEILLCNIAPEATSASETVSS
 Fusarium -----
 Ectocarpus HLGSGSSSSGCCNTPCDANKKGAVKRAASVHSGGGDGSHEMAAVDFATTGDGAAGRSKA
 Naegleria MLSFKTSIDGNLFLTDTTKVHVYKYAAEIMSFKHYQTIDTKGETDELI LEEPINNPLPK

Culex YEDDYEPPKPTMSKMKSSYTVE SFMDIDKRPGHAGVGGGSDLCKFSAAGKGVKPSGGGQ
 Aedes YD-FYEPAKKPNLSKMKSSYTVE SFIDIDKRPTNDLGG-----KYGSSA
 Bipolaris FDMSSKLI EPMTFSFDL FVQIRGRSYMRPTSLFSLTNIWNTVKIVHSTVGFVSAIRPT
 Ustilago FEIQVDRCSAPAAF SMDLAVS INGRDAKPPGRLMSFIEGS---TSMTKTS AIFEVRLVPP
 Neurospora -----
 Nectria -----
 Botryotinia -----

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| Syncephalastrum | ----- |
| Medicago | ----- |
| Volvox | LNFAASRAAQLELLARRAGSAERIDRMGHTSPVFTDRPQQEGSCNGVSRGSAAAASLTSSP |
| Fusarium | ----- |
| Ectocarpus | SSRRASSRTGQTPQRQTVAGRTRSRVSMAPATLRSVR----- |
| Naegleria | KRKLTEEPVDTTICDADISPNCCVIAVLDSSMKVRLFPLQKRSNAEYINMLNLCLINNYD |
| Culex | VAQVKSQNI AAGTPSMSSTSSGYGSQAVSCSNLTNDDTYSIRSLSVGETP----- |
| Aedes | MAKVKSQNI AAGTPSMSSTSSGYGSQAVSCSNLTNDDSYSIRSLSVGETPGYTDENDQE |
| Bipolaris | SVKRATDLWRMNTKDDYIKGEEQLAGWTPRGVSLVRDFINVEKRRRRVAE IETAR----- |
| Ustilago | MMKRPCELWRLDTGSKYVRGQEMLGGWKARGVSLVGDHAALVQRERRRAEVEGVR----- |
| Neurospora | ----- |
| Nectria | ----- |
| Botryotinia | ----- |
| Syncephalastrum | ----- |
| Medicago | ----- |
| Volvox | LLPHPLPIMNGTAAKLLAAGIRGGGLRWLLAYIRTTVTDGHHQRINASPES----- |
| Fusarium | ----- |
| Ectocarpus | ----- |
| Naegleria | RWDLFASIKKLVSP EEIT TIGAEFEQCRLKLENS SKNVIYIYSLEMFIFSIYL----- |
| Culex | -----ETMSP--SNNVLR SNNPLMKDVVSFDELNGNRGGDLLEQEA----LAY |
| Aedes | I SELDSPFSPFAETMSPAISSEFPKRVNPF LKDVANFDQLNGNQGE EYDDERATELHQM Y |
| Bipolaris | -----SVLSSKALSIP--TSALASSKD----KPLDDAQRALLQR----IISLWKTKKAP- |
| Ustilago | -----ATLKGRS AMMRNVDDANAESKEEL AARVVAVWQRAVRDSKVG VVIGVQPSTNAAS |
| Neurospora | ----- |
| Nectria | ----- |
| Botryotinia | ----- |
| Syncephalastrum | ----- |
| Medicago | ----- |
| Volvox | ----- |
| Fusarium | ----- |
| Ectocarpus | ----- |
| Naegleria | ----- |

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| Culex | NSNAKRASEPAVMTGS-RDTMIDEEDEGVVN---EQEVEEDEEVIAMDESHVSSTADDD |
| Aedes | NNNLKRASEPAILSSSSASEMINEEDEGVDEQGGDVEEDEEEETTRTIEEVGEEQMQQQE |
| Bipolaris | -----AEIILNSTN-----LEPPTNGAAFAPR-----SSSPSPSPT |
| Ustilago | AGGTTCKTGADGLVGMFAAPSAVDGTNGLGIDNLSASSSPAKIERTRSTWSSTAPAPAPA |
| Neurospora | ----- |
| Nectria | ----- |
| Botryotinia | ----- |
| Syncephalastrum | ----- |
| Medicago | ----- |
| Volvox | ----- |
| Fusarium | ----- |
| Ectocarpus | ----- |
| Naegleria | ----- |
| Culex | HLQHEDVVDEENNSSKLLQSDVMENSFSTPSKHENIPDWVVVGESVQIRPYNTSGVLSF |
| Aedes | ECNMNETVDEENNSSKLMNDSVMESSFTTPSKHENIPEWVVVGESVQIRPYNTSGVIAF |
| Bipolaris | P-----SLTATVRFIPKNPNLMKASYLLTPDPTNTR-WTRRYVELRKPYLHIYSTDG- |
| Ustilago | PSAPAAPAALTAIVALLPRTATTSHRGLWIPILETITDTWVRRFLVLRPFLHIYESNAQ |
| Neurospora | ----- |
| Nectria | ----- |
| Botryotinia | ----- |
| Syncephalastrum | ----- |
| Medicago | ----- |
| Volvox | ----- |
| Fusarium | ----- |
| Ectocarpus | ----- |
| Naegleria | ----- |
| Culex | VGGTHFQGGTWIGVELDTPGKNDGTVQGIQYFSCRPKHGIFVRVDKLILDKRGRAMREL |
| Aedes | VGGTHFQGGTWIGVELDTPGKNDGTVQGIQYFNCKQKHGIFVRVDKLILDKRGRAIREL |
| Bipolaris | -DEINAINISTARIDHSPQIAKLLGGVQNQHSNSANGSGGAGVYKDVVFAVFARSNTYIF |
| Ustilago | VDEVMVINVEAVRVEYDENTERLLG-----KQNVFAVYTANNSYFF |
| Neurospora | ----- |
| Nectria | ----- |
| Botryotinia | ----- |
| Syncephalastrum | ----- |

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| Medicago | ----- |
| Volvox | ----- |
| Fusarium | ----- |
| Ectocarpus | ----- |
| Naegleria | ----- |
| | |
| Culex | KRAEKMKAEFGGQKSGGQKAVSANGPRK-- |
| Aedes | KRAEKMKGW----- |
| Bipolaris | RARSEREKIEWILRLDQSYFSSGEGSEESA |
| Ustilago | QADSDKDRQVWMKLLDGSYN--GDAGHVFC |
| Neurospora | ----- |
| Nectria | ----- |
| Botryotinia | ----- |
| Syncephalastrum | ----- |
| Medicago | ----- |
| Volvox | ----- |
| Fusarium | ----- |
| Ectocarpus | ----- |
| Naegleria | ----- |