Fig. 25-3. Alignment of the initiation proteins of P2 and some P2-like phages. The amino acids were aligned using the CLUSTAL X program (58). Amino acids identical in at least 4 proteins are indicated by dark gray shadings. The common motifs for proteins initiating rolling-circle replication are boxed (61, 74). The location of P2 *ori* (in the corresponding DNA sequence), and the amino acid in phage 186 believed to interact with the REP protein, are indicated by arrowheads.

```
P2 A       M......... .....AVKAS GRFVPPSAFA AGTGKMFTGA YAWNAPREAV
186 A      M......... ....TGVVYA FPWNAPRSAI ASSYLTYDQQ HRRDRMFAAL
K139 rep   M......... .......AQS FFQDVPPYLA KYFAERYIRT YEKKGARAAN
HP1 rep    MQSMWEQQRN NNLTAKNAHM AVVACERYQA AENGHKFDRT LLPFDESCYT
HP2 rep    MQSMWEQQRN NNLTAKNAHM AVVACERYQA AENGHKFDRT LLPFDESCYT


P2 A       GRERPLTRDE MRQMQGVLST INRLPYFLRS LFTSRYDYIR RNKSPVHGFY
186 A      LHARKVLFLQ PECVRFDVYR TAAVLEQNQG SQRANAFLIS FCKKALPRLE
K139 rep   SFLREKMHPA KERVLKVLQQ YKQLPNTQKV ALLSKEFEDG ..EDPFHPVF
HP1 rep    PLQLELFATN PVDFEFIEQK LENLPRQRQR EYFRKLYLKA YRSVKDDGSI
HP2 rep    PLQLELFATN PVDFEFIEQK LENLPRQRQR EYFRKLYLKA YRSVKDDGSI


P2 A       FLTSTFQRR. ....LWPRIE RVNQRHEMNT DAS....... ..........
186 A      LVAKKYECSG INSNVSAAVF DGHFDTQLMQ YLA....... ..........
K139 rep   FTEYGNPED. .......... .IKSKQVSFD FEK....... ..........
HP1 rep    AFLLGNKQRR HANDYLRDIL DVRLQKVFSQ YNVNVDFLQA FINTPQWLLS
HP2 rep    VFALGNKQRR YANDYLRNVL DVRLQKVFSQ YNVNVDFLQA FINTPQWLLS


P2 A       .LLFLAERDH YARLPG.... .......... .......... ..........
186 A      .SRMVNMVAR FNRLPD.... .......... .......... ..........
K139 rep   .DEKDRKPVK QRLLAE.... .......... .......... ..........
HP1 rep    VKDEMQQAVQ FSTVPTREEL AKHYNELHYS GFHFRLLGTQ QKQKQLPFYL
HP2 rep    VKDEMQQAVQ FSTVPTREEL AKHYNELHYS GFHFRLLGTQ QKQKQLPFYL

                                  ↓
P2 A       MNDKELKKFA ARISSQLFMM YEELSDAWVD AHGEKESLFT DEAQAHLYGH
186 A      MSRADIDLLA ADIAN...FI RAELADIDDT GFSELKTLYT ......WYMR
K139 rep   LEQDELRDMA FRIAK...IM EAYLQLTASR KHADREEDVD QAVVDAYEAL
HP1 rep    ITESKLKKMA YEMATAFIRF QCDCSHFLKN GIEKDNEGDI QGYFYQLYKW
HP2 rep    ITESKLKKMA YEMATAFIRF QCDCSHFLKN GIEKDNEGDI QGYFYQLYKW


P2 A       VAGAARAFNI SPLYWKKYRK GQ.MTTRQAY SAIARLFNDE WWTHQLKGQR
186 A      AGFISLQFNV TPPKWERVTK KY.FCEDEIA PAVMRMFNEV WWRGRLRRIA
K139 rep   AHFCTQTFGI KAP....RKY QK.QTHLSAS SDIMRMISDS WWLGRLVKVR
HP1 rep    CGEIAFSAGF KIPHWEKIEN DKRIKAEHID STLIRLTCEK WWFKQMRDIQ
HP2 rep    CGEIAFSAGF KIPHWEKIEN DKRIKAEHID STLIRLTCEK WWFKQMRDIQ


P2 A       MRWHETLLIA VGEVNKDRSP YASKHAIRDV RARRQANLEF LKSCDLENRE
186 A      AAWREHLQIA VGNVSKKRHA YASKNCVTDW REQKRRTREF LKGLDLED.E
K139 rep   KIMREHLAIA MGQVSNNASP YASWDCVREH QEQQQRNYEA IKNMVLFDEE
HP1 rep    KRMVEHIAIA CGEVRANAAS YISNQSFQEW QLQQRKNHDY LRAMIIENID
HP2 rep    KRMVEHIAIA CGEVRANAAS YISNQSFQEW QLQQRKNHDY LRAMIIENID


P2 A       TGER.IDLIS KVMGSISNPE IRRMELMNTI AGIERYAAAE GDVGMFITLT
186 A      EGNR.ISLIE KYDGSVANPA IRRCELMARI RGFENICNEL GYVGEFYTLT
K139 rep   TEEE.HDLWD MVKKSVSNPA IRRHELMVRC RGCEDIGNEL GLQGLFLTLT
HP1 rep    NPEEQVELFD MFLKSSSNPA LRRNEMMVRL RGLEEWAEEN NNEALFLTLT
HP2 rep    NPEEQVELFD MFLKSSSNPA LRRNEMMVRL RGLEEWAEEN NNEALFLTLT
                                                       Motif 1

P2 A       APSKYHPTRQ VGKGESKTVQ LNHGWNDEAF NPKDAQRYLC HIWSLMRTAF
186 A      APSKYHATTK AGYRNSK... ....WN..GA SPSDTQSYLT GLWARIRAKL
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K139 rep   TPSKYHNSYK KGGFIDH... ....WN..GA SPRDAQAYLN KKWQLIRAKL
HP1 rep    APSSFHAGNG NKK....... ....WL..GV NPRETQNYLN KVWQQFRALL
HP2 rep    APSSFHAGNG NKK....... ....WL..GV NPRETQNYLN KVWQQFRALL
```

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```
P2  A      KDNDLQVYGL RVVEPHHDGT PHWHMMLFCN PRQRNQIIEI MRRYALKEDG
186 A      HREEIRIFGI RVAEPHHDGT PHWHMLMFML PEDVERVRLI IRDYAWEEDH
K139 rep   NRDEIRWFGV RVAEPHHDGT PHWHLLIWVR KEDISAVRDT FITYATEEDR
HP1 rep    SKRNIKFYGM RVAEPHKDGT PHWHALAYVP AEHKEEVIRL FKQKALELDG
HP2 rep    SKRNIKFYGM RVAEPHKDGT PHWHALAYVP AEHKEEVIRL FKQKALELDG
                              Motif 2

P2  A      DERG...... .......... ....AARNRF QAKHLN..QG GAAGYIAKYI
186 A      YELRSDK... .......... ....AKKARF HAEAIDPEKG SATGYVAKYI
K139 rep   GELHPEFEKE KQKPFRKGVY VGPLDYRPRC DFGYIDPTKG TATGYIAKYI
HP1 rep    NEKG...... .......... ....AAEHRC KVEKCDKTKG SATAYIAKYI
HP2 rep    NEKG...... .......... ....AAEHRC KVEKCDKTKG SATAYIAKYI
                                                         Motif 3

P2  A      SKNIDGYALD GQLDND.TGR PLKDTAAAVT AWASTWRIPQ FKTVGLPTMG
186 A      SKNIDGYALD GETDDE.SGE LLKETAPAVS AWAARWHIRQ FQFIGGAPVT
K139 rep   SKNIDGYAMD GDISDE.TGK PVKDMARNVS AWKSRWSIRQ FQFFGGAPVT
HP1 rep    AKNIDGFALA GEVSDEDPTL SLHDNALRVR AWASRWGIRQ FQFYGGASIC
HP2 rep    AKNIDGFALA GEVSDEDPTL SLHDNALRVR AWASRWGIRQ FQFYGGASIC


P2  A      AYRELRKLPR G......... .......... .......... ..........
186 A      VYRELRRMAD .......... .......... .......... ..........
K139 rep   TYRELRRLAN QNKKAFMEYI FMQERADLIS MYELLHYQLI GAFKPARVMT
HP1 rep    VWRELRRLIS G......... .......... .......... ..........
HP2 rep    VWRELRRLIS G......... .......... .......... ..........

P2  A      .......... ..VSIADEFD ERVEAARAAA DSGDFALYIS AQGGANVPRD
186 A      .......... ..PETARALS VEFAAVHDAA HYGRWADYVN AQGGPFVRRD
K139 rep   NQELVEVIAQ SYEARAKTEI PHVAAVLRSA DEGRWHGYIM NQGGPFVKRK
HP1 rep    .......... ...QADDEII NKAQAAAGIA N..DYAAYME IQGGALAKRA
HP2 rep    .......... ...QADDEII NKAQAAAGIA N..DYAAYME IQGGALAKRA

P2  A      CQTVRVARSP SDEVNEYEEE VERVVGIYAP HLGARHIHIT RTTDWR....
186 A      DLQVRTLYEP RTEFNQYGEE TVCIKGVYDA SIGAGSPILT RLTQWK....
K139 rep   ELLVTNVYQE LPFASPYAEA IRKLEGIATP EQVIKTREKV WTIKRKGKET
HP1 rep    DQPIKLDYET KP.ANKYGEQ RKAIIGLANR FSLKQVISRT KKWQIKKRPQ
HP2 rep    DQPIKLDYET KP.ANKYGEQ RKAIIGLANR FSLKQVISRT KKWQIKKRPQ

                                    ori
                                     ▼
P2  A      .IVPKVPVVE PLTLKS...G IAAPRSPVNN CGKLTGGDTS LPAPTPSEHA
186 A      .IVPKRAVDL AVDVKG...A SAPSRSSVNN C......... ....TGSESD
K139 rep   TEGEAVGFGS EATAFG...G SAASRSSVNN CTDP...... ...FTGQVST
HP1 rep    DFAQRTESMV ERSSTANNSA RSAPWTCVSN CN........ .....RSILE
HP2 rep    DFAQRTESMV ERSSTANNSA RSAPWTCVSN CN........ .....RSNLE

P2  A      AAVLNLVDDG VIEWNEPEVV RALRGALKYD MRTPNRQQRN GSPLKPHEIA
186 A      PPILDLTKP. ....LSRRER RELTNRLRKK KPTTRRKFIH GTDKQNVAIT
K139 rep   QLTRLLQPDR LKGSQNDQIV DEVAISALFK GSTLRLDDET ELKIRPAEVD
HP1 rep    QKIKLLTQP. ...ICAPLSA QKLDYLFKYK RLTIDKYTAL ELTENDVQLV
HP2 rep    QKIKLLTQP. ...ICTPLSA QKLDYLFKYK RLTIDKYTAL ELTENDVQLV

P2  A      PSARLTRSER LQITRIRVDL AQNGIRPQRW ELEALARGAT VNYDGKKFTY
186 A      KTIDEIHSDN RHHNQPGRSP APDGRW
K139 rep   EHGKIRPARL VEVKREVDSD IWCRFEGWEK FEQQMEKLNQ KPQEHSQPDL
HP1 rep    KRNQNMMTSL SPVSRNFQKL KDFHKNQRIQ
HP2 rep    KRNQNMMTSL SPVPRNLQKL KNFHKKQRIQ
```

```
P2 A       PVADEWPGFS TVMEWT
K139 rep   SFFQELEGDW PLA...
```

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