




ClustalLite : Alignement multiple heuristique par la méthode Clustal

Stéphanie Gnanalingam

M2 Bio-informatique parcours biologie informatique

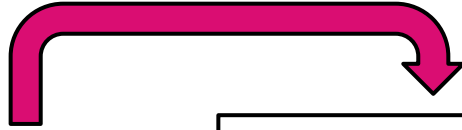
Développement

- <https://github.com/gnanalin/ClustalLite/tree/main>
- CONDA (v.24.7.1)  env_clustallite

Applications

Outil d'alignement
multiple

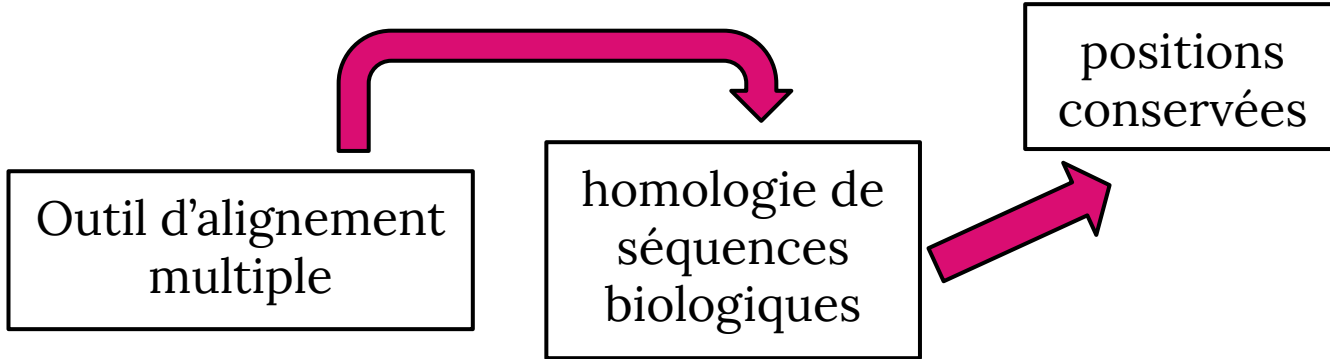
Applications



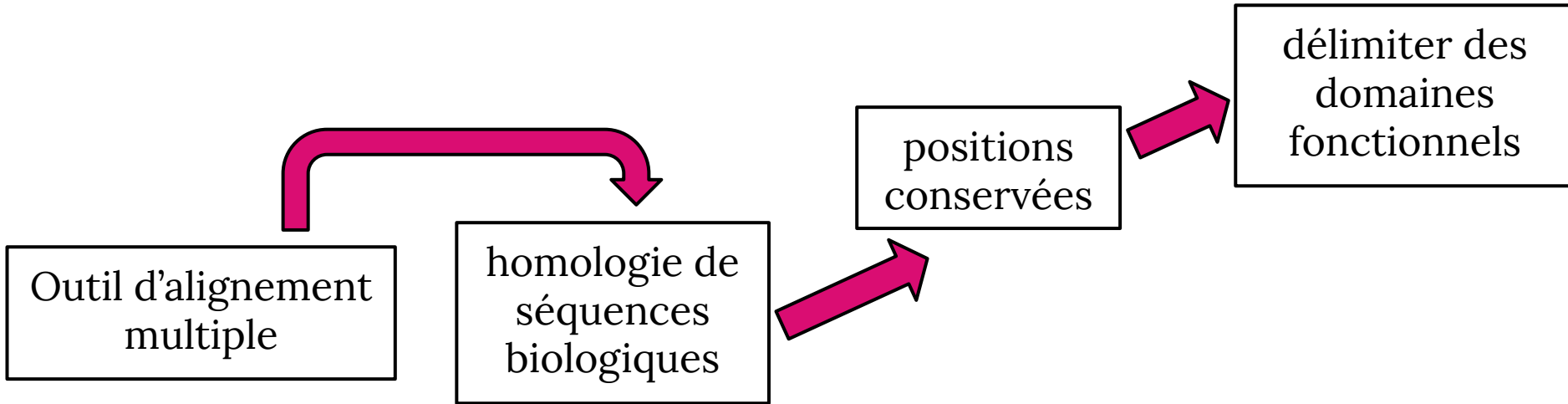
Outil d'alignement
multiple

homologie de
séquences
biologiques

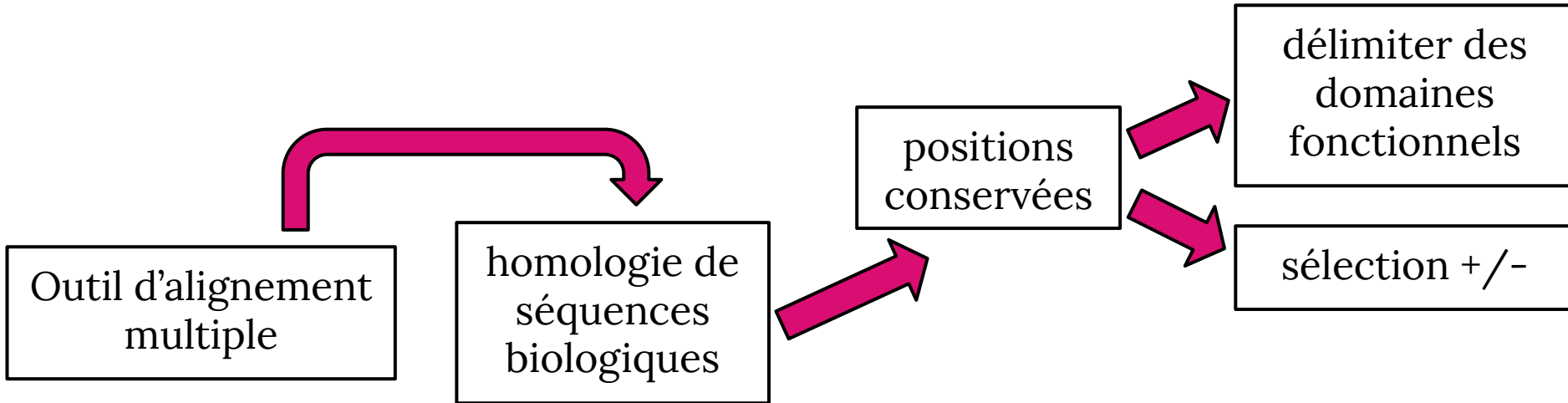
Applications



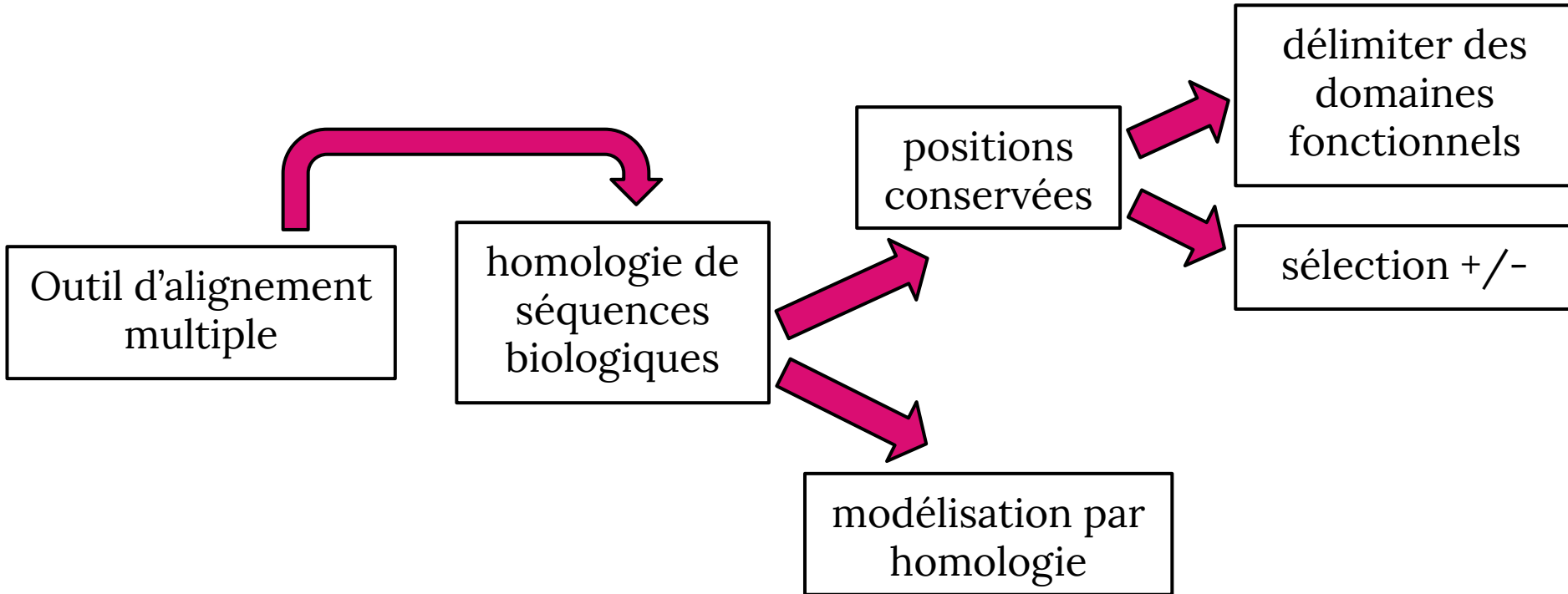
Applications



Applications

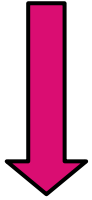


Applications



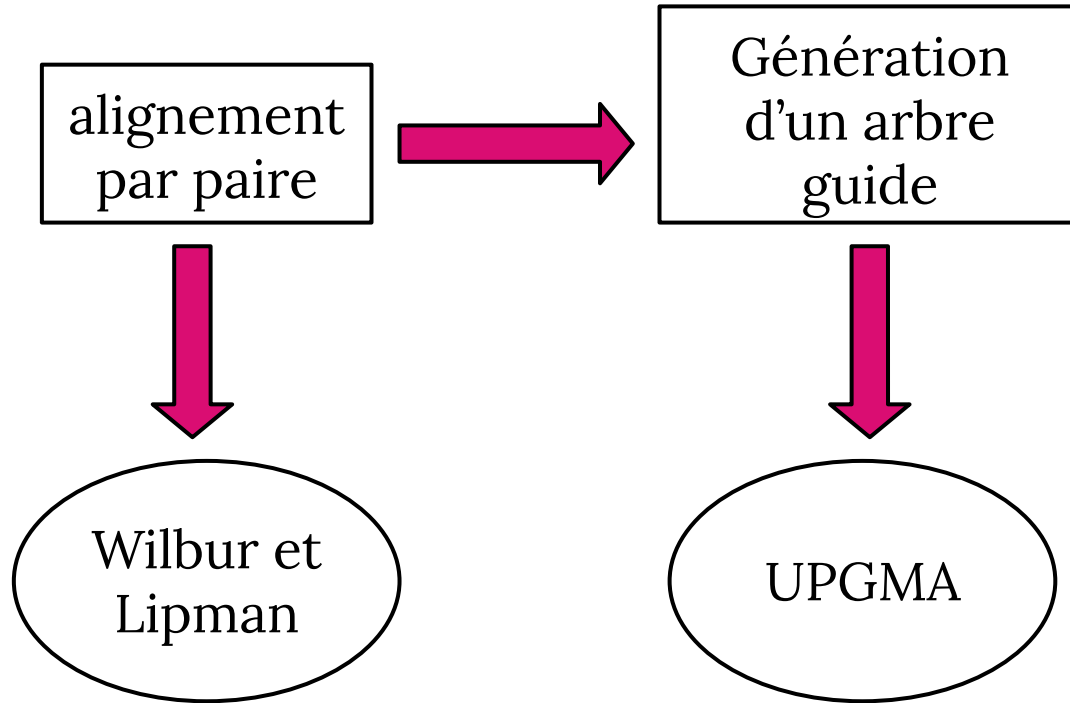
Étapes

alignement
par paire

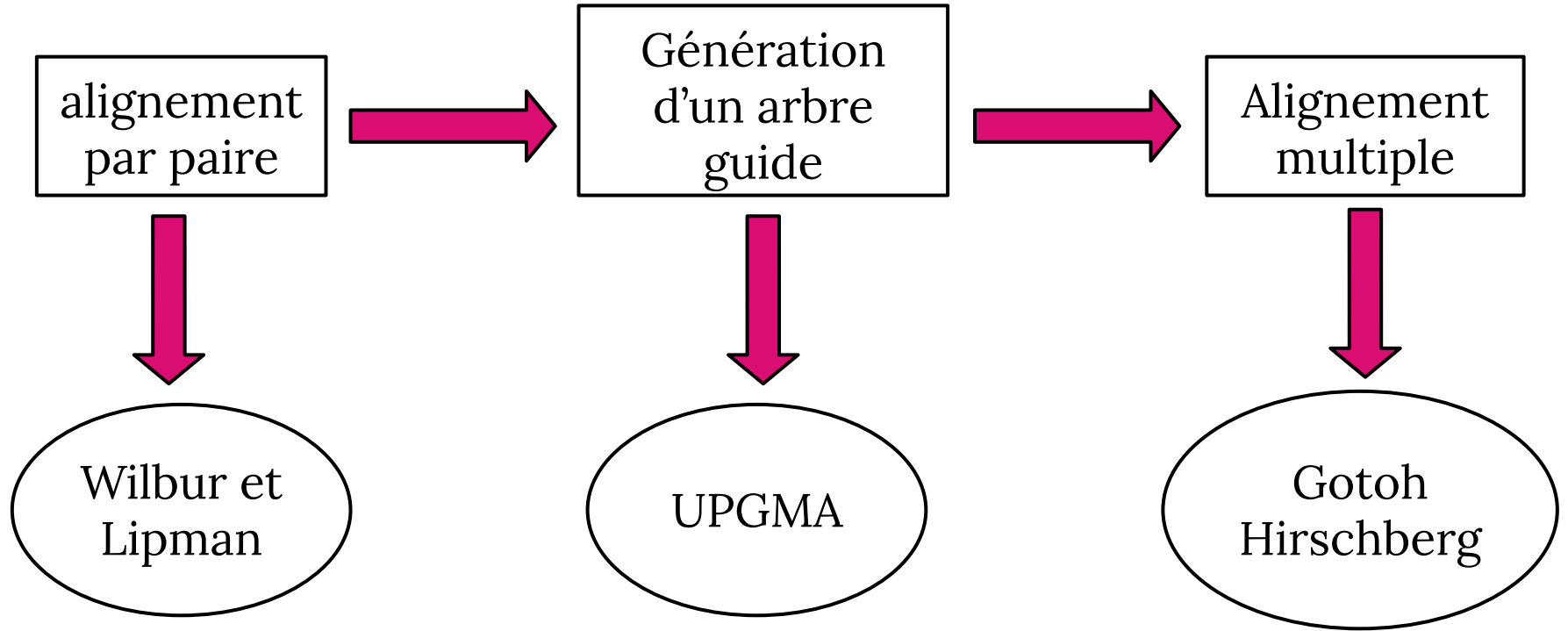


Wilbur et
Lipman

Étapes



Étapes

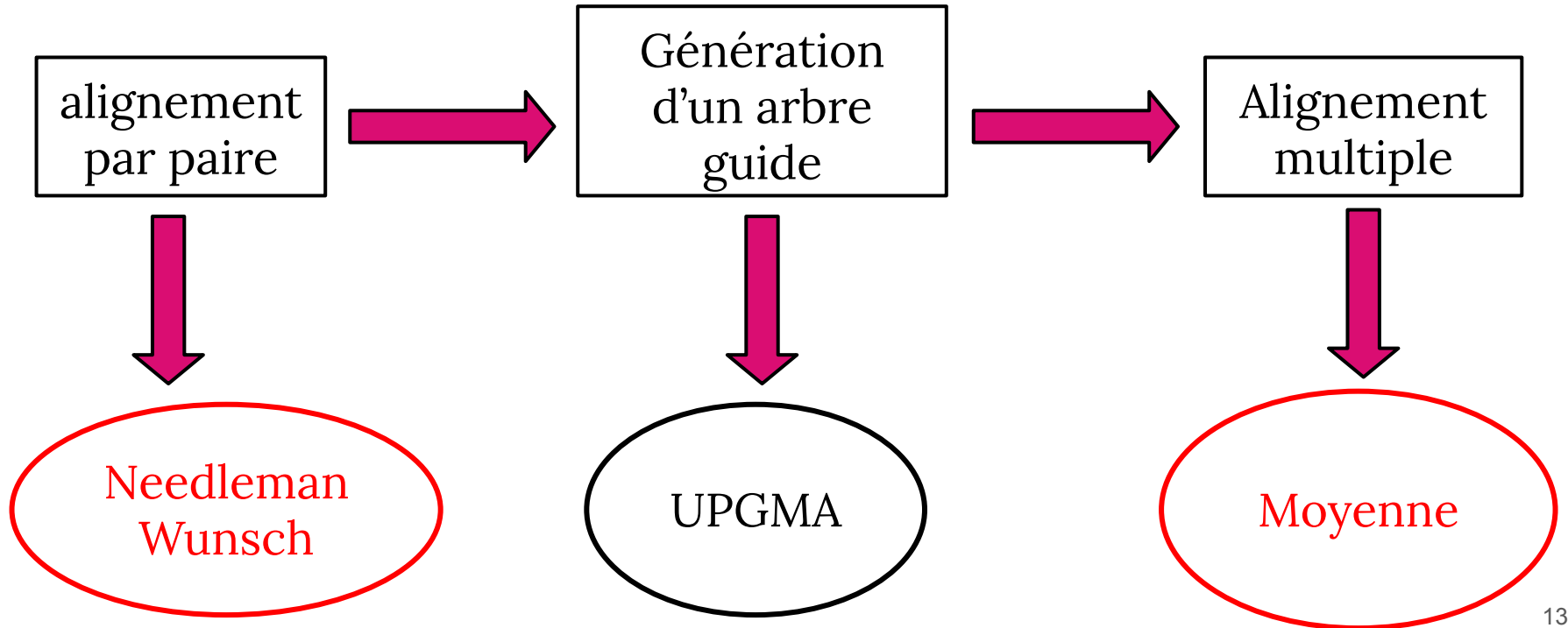


Objectif

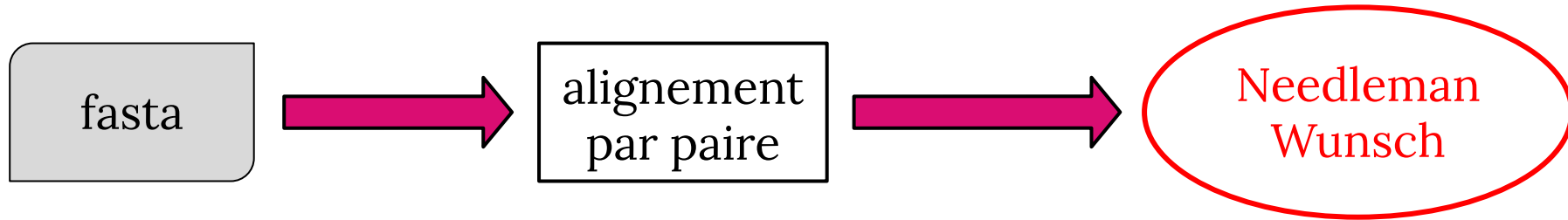
- *Réimplémenter une version simplifiée de Clustal*

Objectif

- Réimplémenter une version simplifiée de Clustal



Les algorithmes



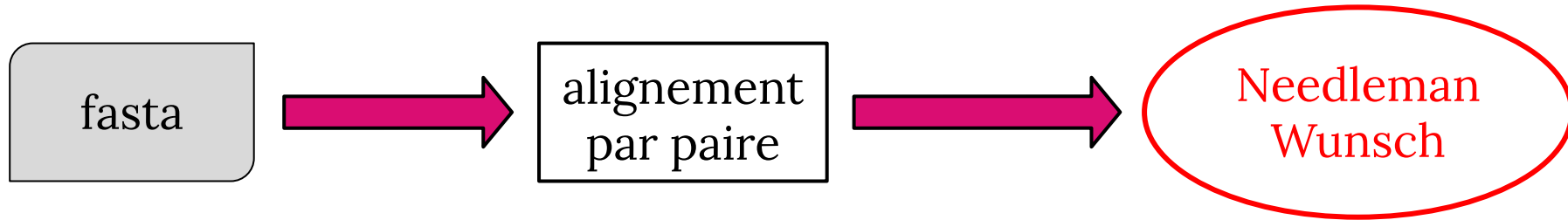
numpy (v2.1.1)

$F(I - 1, J - 1) + S(I, J)$	$F(I - 1, J) - \text{gap}$
$F(I, J - 1) - \text{gap}$	$F(I, J)$

Red arrows indicate dependencies: one from the top-left cell to the bottom-right cell, one from the top-right cell to the bottom-right cell, and one from the bottom-left cell to the bottom-right cell.

- $\text{gap} = 8$
- $S(I, J)$: BLOSUM62
pandas (v2.2.2)

Les algorithmes



$F(I - 1, J - 1) + S(I, J)$	$F(I - 1, J) - \text{gap}$
$F(I, J - 1) - \text{gap}$	$F(I, J)$

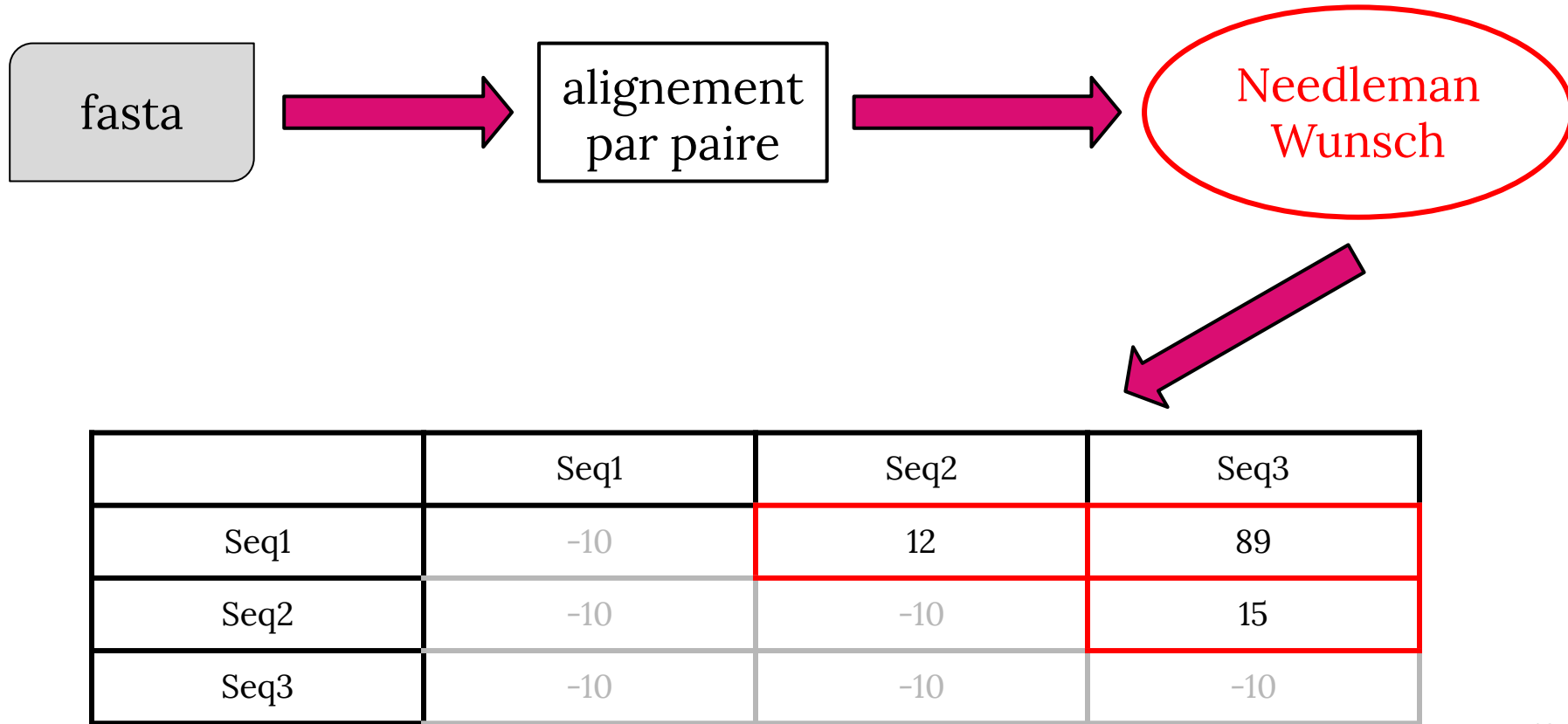
1	1
2	0

0 : diagonale

1: gauche

2: haut

Les algorithmes



Les algorithmes

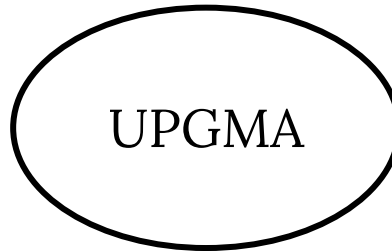
	Seq1	Seq2	Seq3
Seq1	-10	12	89
Seq2	-10	-10	15
Seq3	-10	-10	-10



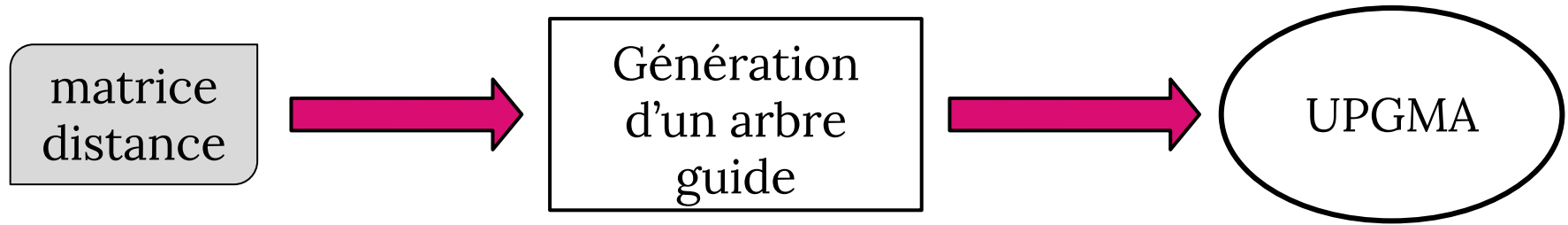
$$\text{matrice distances} = 1 - ((\text{matrice scores} - \text{minimum}) / \text{maximum} - \text{minimum})$$

Les algorithmes

	Seq1	Seq2	Seq3
Seq1	-10	1	0
Seq2	-10	-10	0.96
Seq3	-10	-10	-10



Les algorithmes

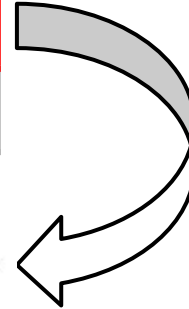


	Seq1	Seq2	Seq3
Seq1	-10	1	0
Seq2	-10	-10	0.96
Seq3	-10	-10	-10

Les algorithmes

	Seq1, Seq3	Seq2
Seq1, Seq3	-10	0.98
Seq2	-10	-10

$$distance((i, j), k) = \frac{n_i * d_{ki} + n_k + d_{kj}}{n_i + n_j}$$



Les algorithmes

	Seq1, Seq3	Seq2
Seq1, Seq3	-10	0.98
Seq2	-10	-10

$$\text{distance}((i, j), k) = \frac{n_i * d_{ki} + n_k + d_{kj}}{n_i + n_j}$$

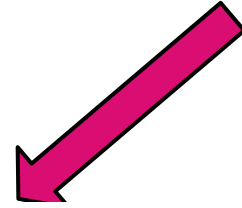
Arbre guide : ((Seq1, Seq3), Seq2)

Les algorithmes

Arbre guide : ((Seq1, Seq3), Seq2)



Alignement multiple



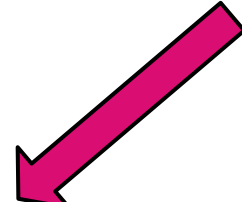
$$\textit{diagonale}(F(i, j)) = F(i - 1, j - 1) + \textit{moyenne}(\textit{cluster1}(i), \textit{cluster2}(j))$$

Les algorithmes

Arbre guide : ((Seq1, Seq3), Seq2)



Alignement multiple



$$\text{diagonale}(F(i, j)) = F(i - 1, j - 1) + \text{moyenne}(\text{cluster1}(i), \text{cluster2}(j))$$

Seq1 : **A**WVED

Seq2 : -TALD

Seq3 : **R**EDAL



$$\text{diagonale} = (S(A, R) - \text{gap}) / 2$$

Résultats

The file exists and is going to be parsed...

Here is the file's content :

Alpha-crystallinBchain: MDIAIHHWPWIRRPFFPFHSPSRLFDQFFGEHLLESDFPTSTSLSPFYLRPPSFLRAPSWFDTGLSEMRLEKDRFSVNLVDVKHFSPEELKVVLGDVIEVHGKHEERQDEHGFISREFHRRYRIPADVDPDLTITSSLSDDGLTVNGPRKQVSGPERTIPITREEKPAVTAAPKK

Alpha-crystallinAchain: MDVTIQHPWFKRTLGPFPYSRLFDQFFGEGLFEYDLLPFLSSTISPYRQSLFRTVLDSGISEVRSRDKFVIFLDVKHFSPEDLTVKVQDDFVEIHGKHNERQDDHGYISREFHRRYRLPSNVDQSALSCSLSADGMLTFCGPKIQTGLDATHAERAIPVSREEKPTSAPSS

Heatshockproteinbeta-6: MEIPVPVQPSWLRRASAPLPGLSAPGRLFDQRFGEGLLEAELAALCPTTLAPYYLRAPSVALPVAQVPTDPGHFSVLLDVKHFSPEEIAVKVVGHEVVEHARHEERPDEHGFVAREFHRRYRLPPGVDPAAVTSALSPEGVLSIQAAPASQAAPPPAAAK

Heatshockproteinbeta-1: MTERRVPFSLLRGPSWDPFRDWYPHSRLFDQAFGLPRLPEEWSQWLGGSSWPGYVRPLPPAAIESPAVAAPAYSRLSRQLSSGVSEIRHTADRWVSLDVNHFAPELTVKTKDGVVEITGKHEERQDEHGYISRCFTRKYTLPPGVDPTQVSSSLSPGTLTVEAPMPKLATQSNEITIPVTFESRAQLGGPEAAKSDETAAK

Heatshockproteinbeta-2: MSGRSVPHAHATAEYEFANPSRLGEQRFGEGLLPEEILTPTLYHGYVVRPRAAPAGEGSRAGASELRLSEGKFQAFLDVSHFTPDEVTVRTVDNLLVSA RHPQRLDRHGFVSREFCRTYVLPADVDPWRVRAALSHDGILNLEAPRGGRHLDTEVNEVYISLLPAPPDPEEEEEAAIVEP

Heatshockproteinbeta-8: MADGQMPFSCHYPSRLRRDPFRDPSLSSRLDDGFGMDPFPDDLTA SWPDWALPRLSSAWPGTLRSGMVPRGPTATARFGVPAEGRTPPPPFGEPWKVCVNVHSFKPEELMVKTKDGYVEVSGKHEEKQEGGIVSKNFTKKIQLPAEVDPVTVFASLSPEGLLIIEAPQVPPYSTFGESSFNNELPQDSQEVTC

Heatshockproteinbeta-3: MAKIILRHLIEIPVRYQEEFEARGLEDCLRDHALYALPGPTIVDLRKTRAAQSPPVDSAAETPPREGKSHFQILLDVVQFLPEDIIIQTFEGWLLIKAQHGTMRDEHGFISRSFTRQYKLPDGV EIKDLSAVLCHDGILVVEVKDPVGTK

Heatshockproteinbeta-7: MSHRTSSTFRAERSFHSSSSSSSSSTSSSASRALPAQDPPMEKALSMFSDDFGSFM RPHEPLAFPARPGGAGNIKTLGDAYEFAVDVRDFSPEDIIVTTSNNHIEVRAEKLAADGTMNTFAHKCQLPEDVDPTSVTSALREDGSLTIRARRHPHTEHVQQTFRTEIKI

Heatshockproteinbeta-9: MQRVGNTFSNESRVASRCPVGLAERNRVATMPVRLLRDSPAAQEDNDHARDGFQMKLDAHGFAPEELVVQVDGQWLMVTGQQQLDVRDPERVSYRMSQKVRHKMLPSNLSPTAMTCCLTPSGQLWVRGQCVALALPEAQTGPSRLGSLGSKASNLTR

Résultats

Here are the Needleman-Wunsch alignments :

Alpha-crystallinBchain: MDIAIHPWIRRPFFPFHSPSRLFDQFFGEHLLESDFP-TSTSLSPFYLRPPSFLRAPS

Alpha-crystallinAchain: MDVTIQHPWFKRTLGPYF-PSRLFDQFFGEGLFEYDLLPFLSSTISPYR-R-QSLFR--T

Alpha-crystallinBchain: WFDTGLSEMRLEKDRFSVNLDVKHFSPEELKVKVLGDVIEVHGKHEERQDEHGFISREFH

Alpha-crystallinAchain: VLDSGISEVRSDRDKFVIFLDVKHFSPEDLTVKVQDDFVEIHGKHNERQDDHGYISREFH

Alpha-crystallinBchain: RKYRIPADVDPLTITSSLSSDGVLTVNGPRKQ--VSG--PERTIPITREEKPAVTAAPKK

Alpha-crystallinAchain: RRYRLPSNVDQSALSCSLSADGMLTFCGPKIQTGLDATHAERAIPVSREEKP--TSAPSS

Alignement score : 466

Alpha-crystallinBchain: MDIAIH-HP-WIRR-PF-FP-FHSPSRLFDQFFGEHLLESDFPTSTSLSPFYLRPPSFL

Heatshockproteinbeta-6: MEIPVPVQPSWLRRASAPLPGLSAPGRLFDQRFGEGLLEAEL--A-ALCPTTL-APYYL

Alpha-crystallinBchain: RAPS WFDTGLSEMRLEKDRFSVNLDVKHFSPEELKVKVLGDVIEVHGKHEERQDEHGFIS

Heatshockproteinbeta-6: RAPS-VALPVAQVPTDPGHFSVLLDVKHFSPEEIAVKVVEHVEVHARHEERPDEHGFVA

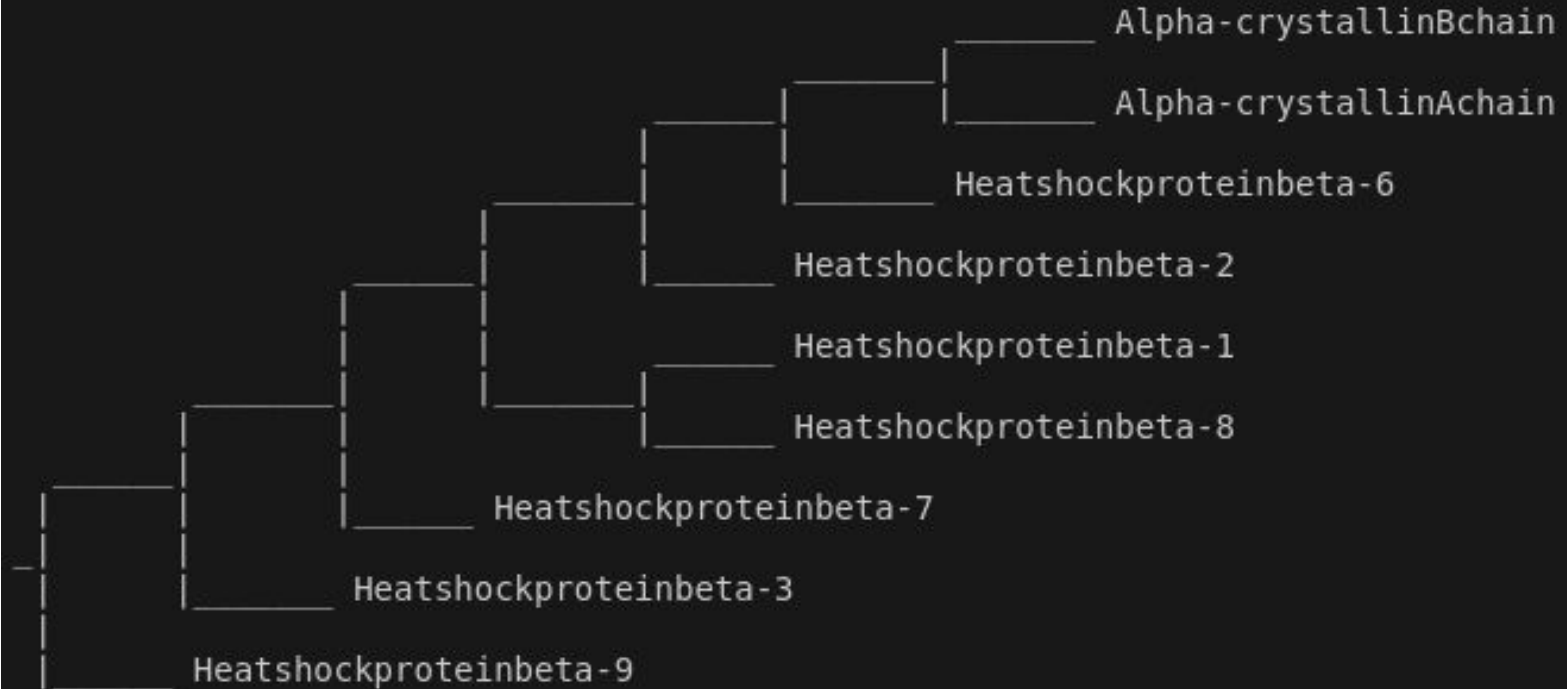
Alpha-crystallinBchain: REFHRKYRIPADVDPLTITSSLSSDGVLTVNGPRKQVSGPERTIPITREEKPAVTAAPKK

Heatshockproteinbeta-6: REFHRRYRLPPGVDPAAVTSALSPEGVLSI-----Q-AAP-AS---AQAPPPA--AA--K

Alignement score : 254

Résultats

Here is the UPGMA algorithm result :



Résultats

Here is the multiple alignment result :

```
Alpha-crystallinBchain: M-DIAIH-HP-WIRR-PFFPF--HS-PSRLFDQFFGEHLLESD-LFP-TSTSLSPFYLRP--P----S-F
Alpha-crystallinAchain: M-DVTIQ-HP-WFKR-TLGP--Y--PSRLFDQFFGEGLFEYD-LLPFLSSTISPY--R---Q----S-L
Heatshockproteinbeta-6: M-EIPVPVQPSWLR--ASAPLPGLSAPGRLFDQRFGEGLLEAE-LAALCPTTLAPYYLRA--P----S--
Heatshockproteinbeta-2: M-S-GRS-VP-HAHP-ATAEYE-FANPSRLGEQRFGEGLLEE-IL--TPTLYHGYVVR--P----R-A
Heatshockproteinbeta-1: MTERRVPFSL-LRGP-SWDPRDWYPSRLFDQAFGLPRLPEE-WSQWLGSSWPGYVRPLPPAAIESPA
Heatshockproteinbeta-8: MADGQMPFSCHYPSRLRRDPFRDSPLSRLDDGFGMDPFPDDLTAW-PDWALP-RLSSAWPGTLRSGM
Heatshockproteinbeta-7: M-SHRTS-ST-F--R-AERSFHSSSSSSSSSTSSSASRALPAQ-DPP-MEKALSMFSDDF--G----S-F
Heatshockproteinbeta-3: M-A-KI--I--LRHL-IEIPVR-Y--QEEFEARGLEDCLRDHA-LYA-LPGPTIV-DLRK--T----R-A
Heatshockproteinbeta-9: M-Q-RVG-NT-FSNE-SR--V-----ASRC-PS-VG--LAERN--R--VAT-M-P--VR-----L
```

```
Alpha-crystallinBchain: LRAP--S-W-FD--T-GLSEMRLEKDRFSVNLVDVKHFSPEELKVKVLGDVIEVHGKHE-E-RQDEH-GF-
Alpha-crystallinAchain: FR---T-V-LD--S-GISEVRSRDKFVIFLDVKHFSPELTVKVQDDFVEIHGKH--E-RQDDH-GY-
Heatshockproteinbeta-6: V----A---L---P--VAQVPTDPGHFSVLLVDVKHFSPEEIAVKVGEHVEVHARHE-E-RPDEH-GF-
Heatshockproteinbeta-2: APAG--E-G-SR--A-GASELRLSEGKFQAFLDVSHFTPDEVTVRTVDNLEVSARHP-Q-RLDRH-GF-
Heatshockproteinbeta-1: VAAPAYSRLSRQLSSGVSEIRHTADRWRVSLDVNHFADELTVKTKDGVVEITGKHE-E-RQDEH-GY-
Heatshockproteinbeta-8: VPRGPTATARFGVPAEGRTPPFPPEGPWKVCNVVHFSKPEELMVKTKDGYEVVSGKHE-E-KQQEG-GI-
Heatshockproteinbeta-7: MRPHSEPLA-FPARPGGAGNIKTLGDAYEFAVDVDRFSPEDIIVTTSNNHIEVRA---E-KLAAD-GT-
Heatshockproteinbeta-3: AQSP--P-V-DS--A-AETPPREGKSHFQILLDVVQFLPEDIIITQFEGWLLIKAQH-G-T-RMDEH-GF-
Heatshockproteinbeta-9: LR-D--S---P--A-AQEDNDHARDGFMKLDAGHFAPEELVVQVDGQWLMVTGQQQLDVRDPERVSYR
```

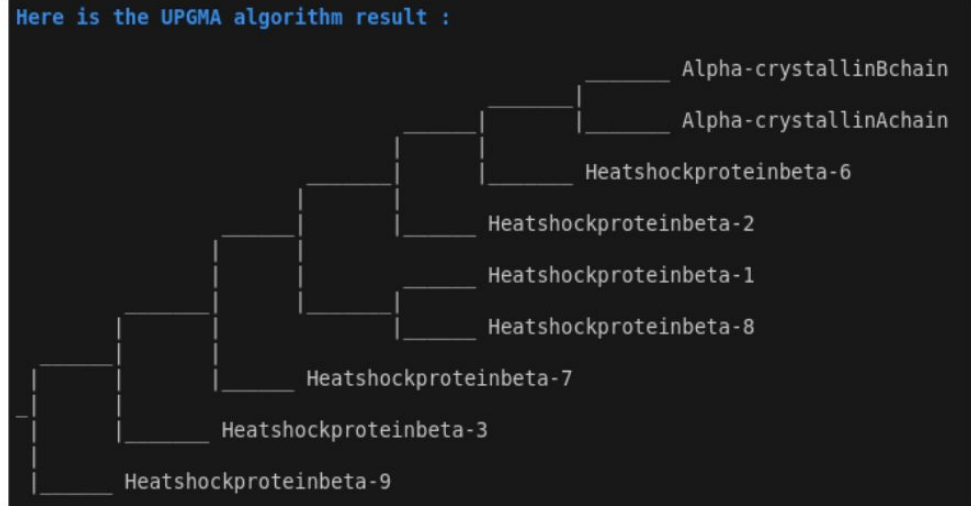
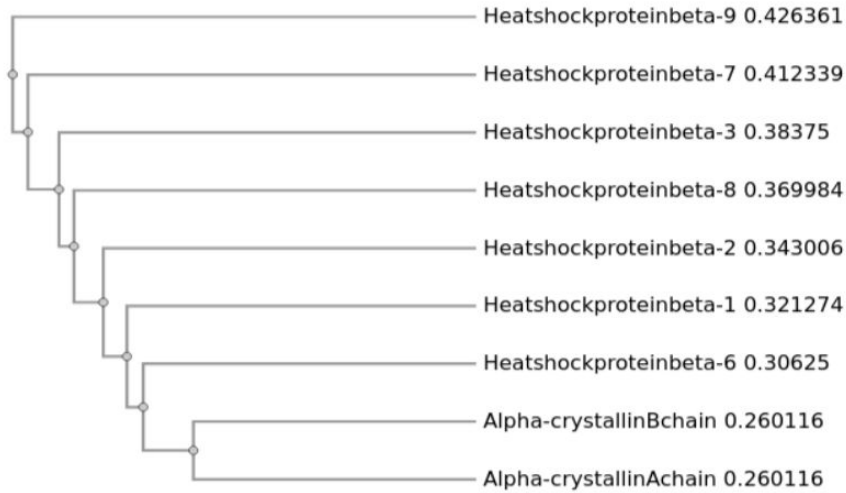
```
Alpha-crystallinBchain: ISREFHRKYRIPADVPLTITSSSSDGVLTVNGPRKQ--VSG--PE-R-T-IPITR-EE-KPAV-TAA-
Alpha-crystallinAchain: ISREFHRRYRLPSNVDSALSCSLSDAGMLTFCGPKIQTGLDATHAE-R-A-IPVSR-EE-KP---TSA-
Heatshockproteinbeta-6: VAREFHRRYRLPPGVDPAAVTSALSPEGVLSI-----Q---A-----A--PASA-QA-PP---PAA-
Heatshockproteinbeta-2: VSREFCRTYVLPADVDPWRVRAALSHDGILNLEAPRGGRHLDTEVNEVYISLLPAPP-DP-EEEE-EAAI
Heatshockproteinbeta-1: ISRCFTRKYTLPPGVDPQTQVSSSLSPGTLTVEAP-MP-KLATQSNITIPVTTFESRAQLGGPEAAKSDE
Heatshockproteinbeta-8: VSKNFTKKIQLPAEVDVPTVFASLSPEGLLIEAPQVP-PYST-FGE-S---SF-NN-EL--PQ--DSQE
Heatshockproteinbeta-7: VMNTEFAHKCQLPEDVDPTSVTSALREDGSLTIRARRHP-H--T---E-H---V---Q-QT--F--RTE-
Heatshockproteinbeta-3: ISRSFTRQYKLPDGVIEIKDLSAVLCHDGILVV-----E-----V---K-D---P---VG-
Heatshockproteinbeta-9: MSQKVHRKM-LPSNLSPTAMTCLTPSGQLWVRGQCVA--LAL--PEAQ-T-GPSRLGS-LGS--KASN
```

```
Alpha-crystallinBchain: PK-K
Alpha-crystallinAchain: PS-S
Heatshockproteinbeta-6: -A-K
Heatshockproteinbeta-2: VE-P
Heatshockproteinbeta-1: TAAK
Heatshockproteinbeta-8: VTCT
Heatshockproteinbeta-7: IK-I
Heatshockproteinbeta-3: -T-K
Heatshockproteinbeta-9: LT-R
```

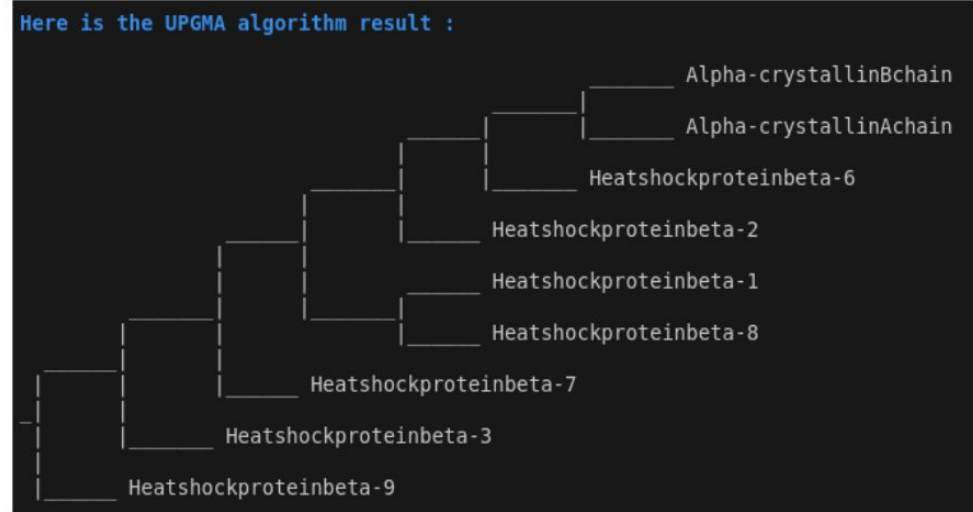
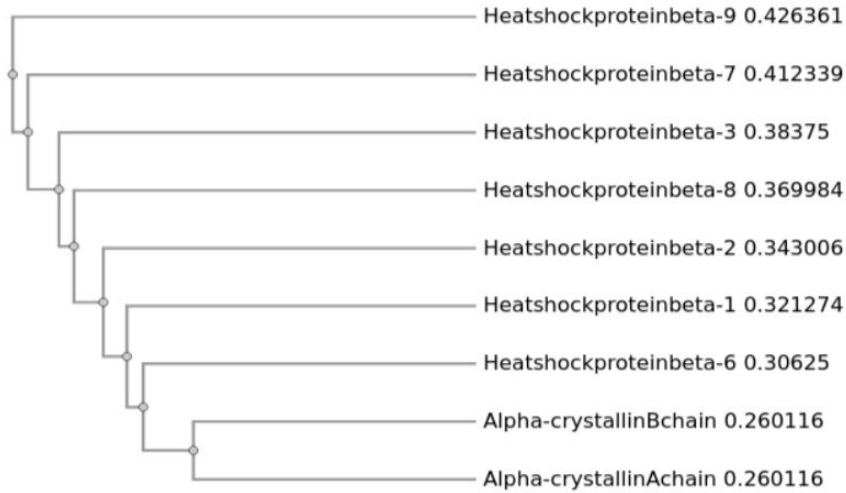
Résultats

9 séquences : COMPLEXITÉ EN TEMPS DE $O(n^2)$	
175 acides aminés	14 secondes
355 acides aminés	37 secondes
860 acides aminés	2 minutes 19 secondes

Résultats : Comparaison

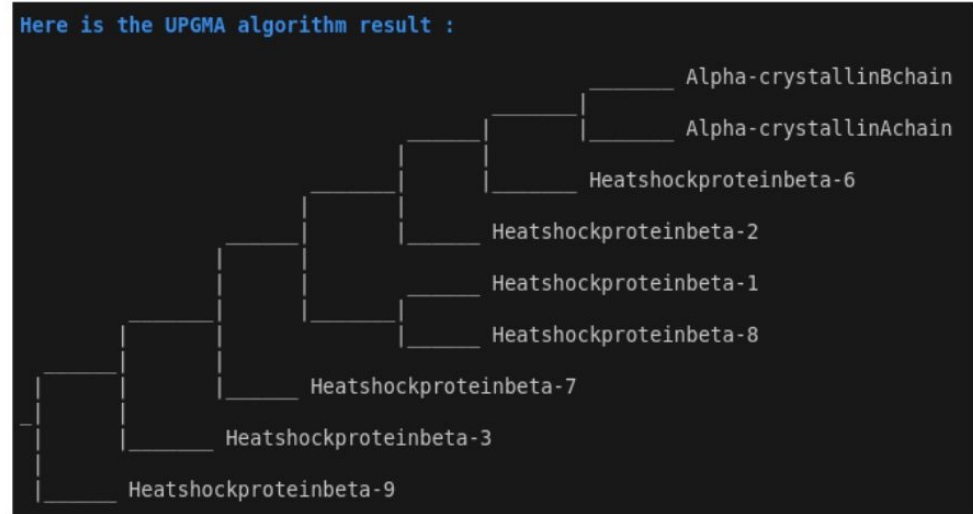
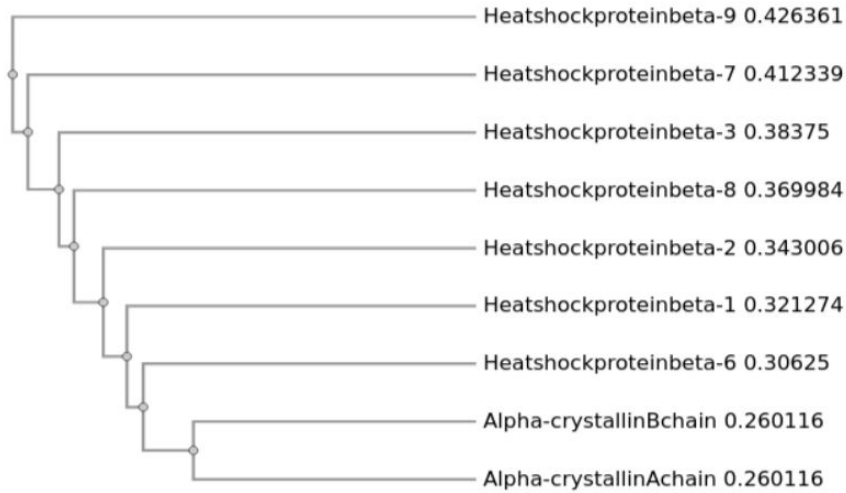


Résultats : Comparaison



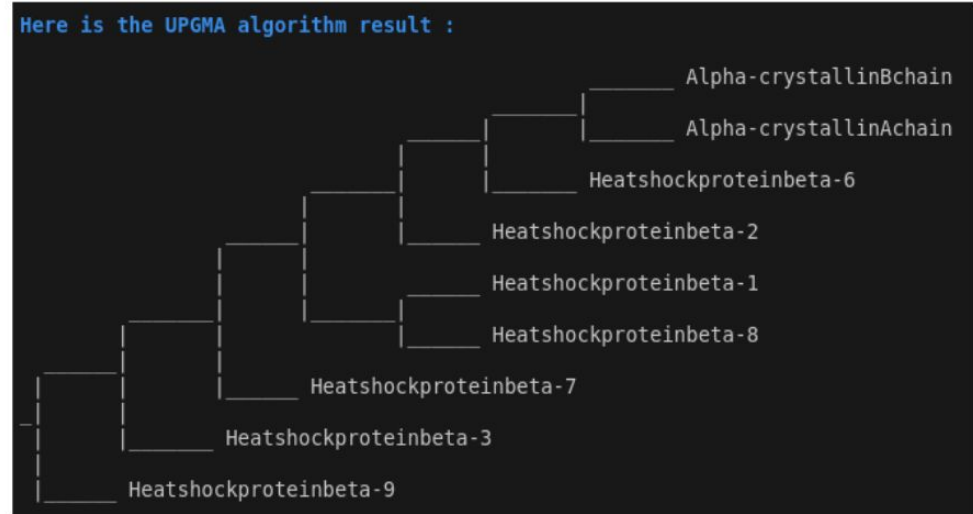
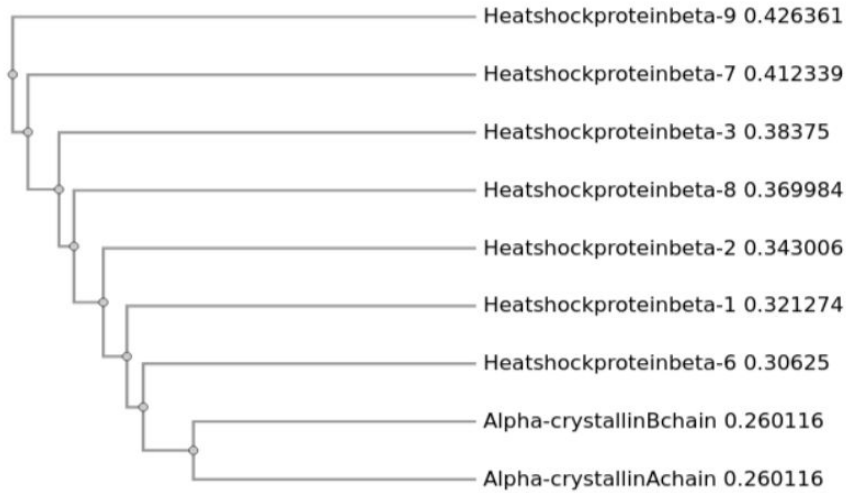
- Needleman-Wunsch VS Wilbur et Lipman

Résultats : Comparaison



- Needleman-Wunsch VS Wilbur et Lipman
- pénalité de gap constante

Résultats : Comparaison



- Needleman-Wunsch VS Wilbur et Lipman
- pénalité de gap constante
- plusieurs méthodes de clusterisation (mBed, k-means, UPGMA)

Résultats : Comparaison

CLUSTAL O(1.2.4) MULTIPLE SEQUENCE ALIGNMENT

HEATSHOCKPROTEINBETA-9	-----MQ-----RVNGTFSNEIR-----VASR	16
HEATSHOCKPROTEINBETA-7	MSHRT-----SSTF-----RAERFSHSSSSSSSSSSSSASRALPAQDPPEKALKE	47
HEATSHOCKPROTEINBETA-3	MAKIIILRL-----DEEF-----ETIPVRYQ-----EEG-----EARGLEDPCDL	30
HEATSHOCKPROTEINBETA-8	MADGQMFSSCHYP-SRL--RRDPFRDPSLSSRL--DDF-----FGMDPFDROLTAS	47
HEATSHOCKPROTEINBETA-2	MSGRSVPHAHP-----ATAEYEFANPSRLG--EQR-----FGGLPEELIT-	40
HEATSHOCKPROTEINBETA-1	MTRRVRFVSLGRPSW--PDFRWYPSHSLRF--DQA-----FGLPRLPESSQW	45
HEATSHOCKPROTEINBETA-6	-----MEIIPVVPVLRASAPLGLSAPGRFL--DQR-----FGHGLEAEALAL	45
ALPHA-CRYSTALLINBCHAIN	-----MDIAIHPPWRTRPPFP--FHSPSRLF--DQF-----FGHGLESLDPLP	40
ALPHA-CRYSTALLINBCHAIN	-----MDVIQHPFKRTLGF--F-YPSRLF--DQF-----FGHGFEDYLLPF	39

HEATSHOCKPROTEINBETA-9	CPS-	-VGLAEINRVAT-	MPV-	RLLRDPAAQEGDNHARDGQFMK	57
HEATSHOCKPROTEINBETA-7	-	MFSDDFGSFMRHPSP-	-	LAFPARPAGAGNITKLGDAYEFA	85
HEATSHOCKPROTEINBETA-3	-	DHALYALPGPT-	TVDLR-	KTRAAGSPPVYGSAAETPPREGKSHFOIL	94
HEATSHOCKPROTEINBETA-8	WPDWALPRLSSAMPTGLRSGMVRP-	-	GPTA-TARFVGPAEGRTPPPFPGKWKV	79	
HEATSHOCKPROTEINBETA-2	-P-	TLHYGVYVPRPAAP-	-	AGEGRGASGLSELRGQFAF	77
HEATSHOCKPROTEINBETA-1	LG-	GSSNGVYRPLPAAETSPAVAAYASRLS	QSLSGVSEIRTHADNRMVS	98	
HEATSHOCKPROTEINBETA-6	CP-	TTLAPPLYLA-	PSV-	ALPVAQVPTDPGHGSFV	98
ALPHA-CRYSTALLINCHAIN	ST-	SLSPFYLR-RP-	PSFLR-APSWITGISEMRLEKRFQV	78	
ALPHA-CRYSTALLINCHAIN	LS-	STISPY-RQ-	SLF-	RTLVDGISEVRSRDKQFVTF	78

HEATSHOCKPROTEINBETA-9 LDHGFAPPELVVQVGDGVEVGVGKQDLVDRPERSVYKQVHKMLPSMTATMC 117
HEATSHOCKPROTEINBETA-7 DVDRFDSPEDIIIVTSGMNIIEVRA---EKKLADEG---TVNMTFATKQCLPEDVDTSVTS 139
HEATSHOCKPROTEINBETA-3 LDVVQFLPEDIITQTFEGWLLIKAQHGRMDEHG---FISRSFTRQYKLPDGVIEKLSA 139
HEATSHOCKPROTEINBETA-8 VNVHSPKPEELWKLWVQGVSEVSGHEEKQEGEG---IVSKNFKTIQLPADVDVPVTFVA 156
HEATSHOCKPROTEINBETA-2 LDVSHFTPDQVTVRTVDNLLVFSARHPQKLDRIHG---FVFSREFCTRYVLPADVDPWIVRA 156
HEATSHOCKPROTEINBETA-1 LDVNHGFAPDELTVTKYGDGVEVGHKEERQDEHG---YISRCFTKYTLPDGVDPQVSS 158
HEATSHOCKPROTEINBETA-6 LDVNHGFSEETAIVKVGVEHVEVHARHEERDEHG---FVAFERHRRYRLPGVDPAAVTS 139
ALPHA-CRYSTALLINBCHAIN LDVKHGFSEELKVKVLGDVIEVHGHEERQDEHG---FISREFHRRYKIPADVPLITS 139
ALPHA-CRYSTALLINACHAIN LDVKHGFSEDLTVKVGQDFDIEVHGKNERQDDHG---YISREFHRRYRLPSNVQSQALSC 131

HEATSHOCKPROTEINBETA-9	CLTPSGQLVMVRGGQVICALPEAQGTG-----SPRLGSLGSKASNLTR----	159
HEATSHOCKPROTEINBETA-7	ALRDGSLDITLRAARPHHTHVHQVQ-TRFTEIKI-----	170
HEATSHOCKPROTEINBETA-3	VLCHDGLTLVVEVDPVGTG-----	150
HEATSHOCKPROTEINBETA-8	SLSPGELLIIAEPQVPSYTFGESSFNNELPDQSQE-----VTCT-----	196
HEATSHOCKPROTEINBETA-2	ALSDGGLNLGQGGHGLDTEVN--EYVTSLLPA-----PPDPEEEEEAAIVP	182
HEATSHOCKPROTEINBETA-1	SLSPGTLTVAEPMKPLAT--QSN-EITTPVTFESRQLQGPEAAKSDEATAK----	205
HEATSHOCKPROTEINBETA-6	ALSPGVLTIQAPASQAAPPPA--AK-----	160
ALPHA-CRYSTALLINBCHAIN	SLSDGVLTVGPGPKIQVQ-----SGP-ERTPTVTREREKPAVTAAPKK-----	175
ALPHA-CRYSTALLINBCHAIN	SLSDGMLTFCGPKITQGLDTALDA--ERATPVSREREKPTSPSS-----	173

Alpha-crystallinBchain: M-DIAIH-HP-WIRR-PFFPF--HS-PSRLFDQFFGEHLLLESD-LFP-TSTSLSPFYLRP--P---S-S-F
Alpha-crystallinAchain: M-DVTIG-HP-WFKR-TLGF--Y--PSRLFDQFFGEGFLFEYD-LLPFLSSSTISPYLR--Q---S---S
Heatshockproteinbeta-6: M-EIIPVQVSWLRAR-APSLGAPLSDRFLDQRFGEGLLEAD-LAALCPPTLAPYYLR--P---S---S
Heatshockproteinbeta-2: M-S-GRS-V-MAHP-ATAEY-FANPSRLGEQRFGEGLLPEE-IL--TPTLYHGYVVR--P---R--R-A
Heatshockproteinbeta-1: MTRRNVPSFL-LRGP-SWDPFRDWYPHSLRFDQAFLGRLPREE-QSWQGLGSSWGPGVYRPLPPAAIESPA
Heatshockproteinbeta-8: MADDGQFFSCHYSRLRRDFRDPDSLHLLDDGFMGDPFDLDTAS-PDWALP-LRSSAWPTGLRSGM
Heatshockproteinbeta-7: M-SHRTS-ST-F--R-AERSFHSSSSSSSSSSSSSSAALRAQ-DPP-MEKALSMFSDDF--G---S-S-F
Heatshockproteinbeta-3: M-A-KI--I--LRHL-IEIPVR-Y--QEEFEAGSRLCRDLA-LYA-LPGPTIV-DLRK-T----R-A
Heatshockproteinbeta-9: M-Q-RVG-N-FSNE-SR-V---ASRC-PS-VG-LAERN-R-VAT-M-P-VR-----

Alpha-crystallinBchain: LRAP--S-W-FD--T-GLSEMRLEKDRFSVNLDVKKHFSPEELKVKVLGDVIEVHGKHE-E-RQDEH-GF-
Alpha-crystallinAchain: FR---T-V-LD--S-GISEVSRSDKDFKVFILVKKHFSPELTKVVKQDDFVEIHGKHE-E-RQDDH-GY-
Heatshockproteinbeta-6: V-----A-L-L--P--VAQVPDPGHFSLVDLVKKHFSPEAAIKVVGEHVHKKH-E-RPDEH-GF-
Heatshockproteinbeta-2: APAG--E-G-SR--A-GASELRLSEGKQAFALVDVSHFTPDENVTRVDNLLVEVSARHP-Q-RLDRH-GF-
Heatshockproteinbeta-1: VAAPAYSRAISRQLSSVSEIRHTADGRVSLDVNVHSPKDELTKTKDGVLETSKHE-E-RQDEH-GY-
Heatshockproteinbeta-8: VPRGTATARGFVPAEGRTPPPFPFGEKPKWCVNVHSPKELMKTKDGVVEVSGKHE-E-QQEG-GI-
Heatshockproteinbeta-7: MRPHSEPLA-PPARPGGAGNIKTLGDAYEFAVLDVRDFSPEDIIVTTSNNHIVRA---E-KLAAD-GT-
Heatshockproteinbeta-3: AQSP--P-V-DS--A-AETPPREGKSHFQILVDVQFLPEDIIQTQFEGWLLKVA--E-RMDEH-GF-
Heatshockproteinbeta-9: LR-D-S--S--P--A-AEQNDHARDGFQMKLDAGFAPEELVQVDGQWLHVTGQQLDVRDPERSVY-

Alpha-crystallinBchain: ISREFHRRKYRIPADVDPILTITSSSSDGLVTVNGPRKQ--VSG--PE-R-T-IPITR-EE-KPAV-TAA-
Alpha-crystallinAchain: ISREFHRRYRLPSNVDSGSSCSLSADGMGLTFCGPKITQGLDATHAE-R-A-IPVSR-EE-KP--TSA-
Heatshockproteinbeta-6: VAREFHRRYRLPGVDPAVTSASDPEGLSLI---Q--Q-A-----A-PASA-QA-PP---PAA-
Heatshockproteinbeta-2: VSREFTCTVYLPADVDPWRVRAALSHDGLNLNEAPGRGRHLDTEVNEVYSLLPAP-PP-EEEE-EAAI-
Heatshockproteinbeta-1: ISRCFCTRYKLPVGPDPVTSSSLSPGGLITVEAP-M-KLATQSNEIIPVTFESPAQLGGPEAAKSDE-
Heatshockproteinbeta-8: VSKNFTKKIQLPAEVDPTVFSASLSEGLLIIEAPQP-PYST-FGE-S--SF-NN-EL-PQ--DSQE-
Heatshockproteinbeta-7: VMNFTFAHKQLPEDVDKTSVSLREDGSLTIRARRHP-H-T--E-H--V--Q-Q-T-F--RTE-
Heatshockproteinbeta-3: ISRSFTQYKQLPDGVEIKLISAVLCHDGLIV-----E--V--K-D--P--V--VG-
Heatshockproteinbeta-9: MSQKVRHKR-LPSNLSPATMCCLTSPGLWVRGQCA--LAL-PEAQ-T-GPSPLKDS-LGS--KASN-

Alpha-crystallinBchain: PK-K
Alpha-crystallinAchain: PS-S
Heatshockproteinbeta-6: A-A-K
Heatshockproteinbeta-2: VE-P
Heatshockproteinbeta-1: TAAK
Heatshockproteinbeta-8: VTCT
Heatshockproteinbeta-7: IK-I
Heatshockproteinbeta-3: -T-K
Heatshockproteinbeta-9: LT-R

Résultats : Comparaison

CLUSTAL O(1.2.4) MULTIPLE SEQUENCE ALIGNMENT

```

HEATSHOCKPROTEINBETA-9  -----MQ-----RVGNTFSNEIR-----VASR      17
HEATSHOCKPROTEINBETA-7  MSHRT-----SSTF-----RAERSFHSSSSSSSTSSASRALPAQDPPEKALS--      46
HEATSHOCKPROTEINBETA-3  MAKILRLHL-----ETPRVQ-----EEF-----EARGLEDCRL--      38
HEATSHOCKPROTEINBETA-8  MADGQMPFSCHYP-SRL--RRDPFRDPSLSRL--DDG-----FGMDPFDOLTAS      47
HEATSHOCKPROTEINBETA-2  MSGRSVPHAHP-----ATAEYEFANPRDG-----EQR-----FGEGGLEPEILT-      40
HEATSHOCKPROTEINBETA-1  MTERRVPFSLRRGSPW-----DPFRDWPYHRGF--DQA-----FGLPRLPEEWSQW      45
HEATSHOCKPROTEINBETA-6  ---MEIPVPVQPSWLRRASAPLPLGLSAPRGF--DQR-----FGGLELEAELAAL      46
ALPHA-CRYSTALLINBCHAIN  ---MDIAIHPWIRRRPFPPF--FHSPPRGF--DQF-----FGHELESOLFFT      48
ALPHA-CRYSTALLINACHAIN  -----MDVTIQHWPKRTLGP--F-YPRRGF--DQF-----FGGLEFEYDLPF      39
    
```

```

HEATSHOCKPROTEINBETA-9  CPS-----VGLAERNRVAT-----MPV--LRLLRSDPAAQEDNDHARDGFMK      57
HEATSHOCKPROTEINBETA-7  ---MFSDDFGSFMRPHSEP-----LAFPARPGGAGNIKTLGDAYEFA      85
HEATSHOCKPROTEINBETA-3  -----DHLYALPGPT--IVDLR--KTRAAQSPVVDAAETPPREGKSHFQIL      74
HEATSHOCKPROTEINBETA-8  WPDNALRLSSAMPTLRSGMVRP-----GPTA-TARFQVPAEGRTPPPFGPEKQVC      99
HEATSHOCKPROTEINBETA-2  -P-----TLYHGYYVPRPAAP-----AGEGSRAGASRLSEKGFQAF      77
HEATSHOCKPROTEINBETA-1  LG-----GSSMPGYRPLPAAAEISPAVAAPAYSRLSRQLSSGVSEIRHTADMRVRS      98
HEATSHOCKPROTEINBETA-6  CP-----TTLAPYYLR-----PSV-----ALPVAQVTPDGHFSVL      77
ALPHA-CRYSTALLINBCHAIN  ST-----SLSPFLY-RR-----PSFLR-APSWIFDGLSEMRLEKGFVSN      78
ALPHA-CRYSTALLINACHAIN  LS-----STISPIY-RQ-----SLF--RTVDSGISEVRSRDRKQVIF      74
    
```

```

HEATSHOCKPROTEINBETA-9  .DAHGFAPEELVVQVQDGLMVTGQQQLDVRDPEVSYVMSQKVHRKMLPSLSPMTATC      117
HEATSHOCKPROTEINBETA-7  VVDRDQSPEDIIVTTSNNHIEVRA---EKLAADG---TMMTFAHKCQLPEDVPTSVTS      139
HEATSHOCKPROTEINBETA-3  .DVVQFLPEDIIQTTFEGWLLIKAQHGTRDEHG--FSSRSFTQYKLPDGVIEIKDLSA      131
HEATSHOCKPROTEINBETA-8  VNVHSFKPEELMWKTDGVEVSGVSGHKEEKQEGG--IVSKNFTKKIQLPAEVDVPTVFA      156
HEATSHOCKPROTEINBETA-2  .DVSHFTPDEVTVRTVDNLLVESARHPQLDRHG--FSSREFCRTYVLPADVDPWRVRA      134
HEATSHOCKPROTEINBETA-1  .DVNHFAPELTVKTKDGVVEITGKHEERQDEHG--VYSRCFTKYTLPPGVDPTQVSS      155
HEATSHOCKPROTEINBETA-6  .DVKHFSPEEIAVKVVEGVHVEHARHEERDQHG--FPAREFHRRYRLPPGVDPAVTS      145
ALPHA-CRYSTALLINBCHAIN  .DVKHFSPEELKVYKVGDIIEVHGKHEERQDEHG--FSSREFHRRYRIPADVDPILTITS      135
ALPHA-CRYSTALLINACHAIN  .DVKHFSPEELTVKVQDDFVEIHGKHNERQDQHG--YYSREFHRRYRLPSNDQSQALS      131
    
```

```

HEATSHOCKPROTEINBETA-9  CLTPSGQLWVRGQCVALALPEAQGTG-----SPRLSGSLGKASNLTR-----      159
HEATSHOCKPROTEINBETA-7  ALREDGSLTIRARRHPHTEHVQQTFRTEIKI-----      170
HEATSHOCKPROTEINBETA-3  VLCHDGLVVEVQDPVGTG-----      150
HEATSHOCKPROTEINBETA-8  SLSPEGLLIEAPQVPVPTGTFGESSFNNELPQDSQE-----VTCT-----      196
HEATSHOCKPROTEINBETA-2  ALSHDGILNLEAPRGGRHLDETVN--EYISLLPA-----PPDPEEEEEAAIIEP      182
HEATSHOCKPROTEINBETA-1  SLSPEGTLVEAPMKLAT--QSN--EITIPVTFSRAQLGGPEAAKSDETAAK--      205
HEATSHOCKPROTEINBETA-6  ALSPEGVLISQAAPASQAAPPAA--AK-----      160
ALPHA-CRYSTALLINBCHAIN  SLSSDGVLTVNGPKRQV--SGP--ERTIPITREKPAVTAAPK-----      175
ALPHA-CRYSTALLINACHAIN  SLSADGMLTFCGPKIQTLGDATHA--ERAIPVSREEKPTAPS-----      173
    
```

```

Alpha-crystallinBchain: M-DIAIH-HP-WIRR-PFFPF--HS-PRLFDQFFGHEHLES-D-LFP-TSTLSLSPFYLRP--P---S-F
Alpha-crystallinAchain: M-DVTIQ-HP-WFKR-TLGP--Y--PRLFDQFFGEGLEFYD-LLPFLSSSTISPIY-R---Q---S-L
Heatshockproteinbeta-6: M-EIPVPVQPSWHLRR-ASAPLPLGSAPRLFDQRFEGGLEAE-LAALCPTTLAPYYLRA--P---S-S-
Heatshockproteinbeta-2: M-S-GRS-V-PAHPR-ATAEYE-FANPRLGEORFEGGLEPPE-IL--TPTLYHGYYVR--P---R-A
Heatshockproteinbeta-1: MTERRVPFSL-LRGP-SWDPRDWPYHRLFDQAFGLPRLPEE-WSQWLGSSSGWPGYVRPLPPAAIESPA
Heatshockproteinbeta-8: MADGQMPFSCHYPSRLRRDPFRDPSLSRLLDGFGMDPFPDDLTA-SW-PDWALP-RLSSAWPGTLRSGM
Heatshockproteinbeta-7: M-SHRTS-ST-F--R-AERSFHSSSSSSSSSTSSASRALPAQ-DPP-MEKALSMFSDDF--G---S-F
Heatshockproteinbeta-3: M-A-KI--I--LRHL-IEIPVR-Y--QEEFEARGLEDCLRDHA-LYA-LPGPTIV-DLRK--T---R-A
Heatshockproteinbeta-9: M-Q-RVG-NT-FSNE-SR--V-----ASRC-PS-VG--LAERN--R--VAT-M-P--VR-----L
    
```

```

Alpha-crystallinBchain: LRAP--S-W-FD--T-GLSEMRLEKDRFSVLDVKHFSPEELKVKVLGDVIEVHGKHE-E-RQDEH-GF-
Alpha-crystallinAchain: FR---T-V-LD--S-GISEVRSRDRKDFVLDVKHFSPEELTVKVQDDFVIEHGKHN-E-RQDDH-GY-
Heatshockproteinbeta-6: V-----A--L--P--VAQVPTDPGHFSVLDVKHFSPEEIAVKVVEGVHARHE-E-RPDEH-GF-
Heatshockproteinbeta-2: APAG--E-G-SR--A-GASELRLSEGKQAFDVSHTFPDEVTVRTVDNLLVESARHP-Q-LDRH-GF-
Heatshockproteinbeta-1: VAAPAYSRLSRQLSSGVSEIRHTADRWRLVDVNHFAPELTVKTKDGVVEITGKHE-E-RQDEH-GY-
Heatshockproteinbeta-8: VPRGPTATARFGVPAEGRTPPPPFGPEKWKVCNVHFSKPEELMWKTDGVEVSGKHE-E-KQDEH-GI-
Heatshockproteinbeta-7: MRPHSEPLA-FPARPGGAGNIKTLGDAYEFAVDVDRDQSPEDIIVTTSNNHIEVRA---E-KLAAD-GT-
Heatshockproteinbeta-3: AQSP--P-V-DS--A-AETPPREGKSHFQILLDVVQFLPEDIITQTFEGWLLIKAQHG-T-RMDEH-GF-
Heatshockproteinbeta-9: LR-D--S---P--A-AQEDNDHARDGFMKLDAGHFAPEELVVQVQDGLMVTGQQQLDVRDPERVSYR
    
```

```

Alpha-crystallinBchain: ISREFHRRYRIPADVDPILTITSLSSDGVLTVNGPRKQ--VSG--PE-R-T-IPITR-EE-KPAV-TAA-
Alpha-crystallinAchain: ISREFHRRYRLPSNDQSQALSGLSADGMLTFCGPKIQTLGDATHAE-R-A-IPVSR-EE-KP--TSA-
Heatshockproteinbeta-6: VAREFHRRYRLPPGVDPAVTSVLSPEGVLSI-----Q-----A-----A-PASA-QA-PP--PAA-
Heatshockproteinbeta-2: VSREFCRTYVLPADVDPWRVRAALSHDGLNLEAPRGGRHLDETVNEVYISLLPAPP-DP-EEEE-EAAI-
Heatshockproteinbeta-1: ISRCFTKRYKTLPPGVDPTQVSSLSPEGLTVEAP-MP-KLATQSNIEITPVTFSRAQLGGPEAAKSDE
Heatshockproteinbeta-8: VSKNFTKILQPAEVDVPTVFAVLSPEGLLIEAPQV-PYST-FGE-S--SF-NN-EL--PQ--DSQE
Heatshockproteinbeta-7: VMNTFAHKCQLPEDVPTSVTSALREDGSLTIRARRHP-H--T---E-H---V---Q-QT--F---RTE-
Heatshockproteinbeta-3: ISRSFTQYKLPDGVIEIKDLSALCHDGLLVV-----E-----V---K-D---P---VG-
Heatshockproteinbeta-9: MSQKVHRKM-LPSNLSPMTATCLTPSGQLWVRGQCV--LAL--PEAQ-T-GPSRLGS-LGS--KASN
    
```

```

Alpha-crystallinBchain: PK-K
Alpha-crystallinAchain: PS-S
Heatshockproteinbeta-6: -A-K
Heatshockproteinbeta-2: VE-P
Heatshockproteinbeta-1: TAAK
Heatshockproteinbeta-8: VTCT
Heatshockproteinbeta-7: IK-I
Heatshockproteinbeta-3: -T-K
Heatshockproteinbeta-9: LT-R
    
```


Résultats : Comparaison

CLUSTAL O(1.2.4) MULTIPLE SEQUENCE ALIGNMENT

```

HEATSHOCKPROTEINBETA-9      -----MQ-----RVGNTFSNESR-----VASR      17
HEATSHOCKPROTEINBETA-7      MSHRT-----SSTF-----RAERSFHSSSSSSSSSSSSASRALPAQDPPEKALS--      46
HEATSHOCKPROTEINBETA-3      MAKILRLHL-----ETPVRYQ-----EFGLEEDCRLL-----      38
HEATSHOCKPROTEINBETA-8      MADGQMPFSCHYP-SRL--RRDPFRDPLSSRL--DQG-----FGMDPFPDGLTAS      47
HEATSHOCKPROTEINBETA-2      MSGRSVPHAHP-----ATAEYEFANPSRLG--EQR-----FGEGLLEPEILIT--      48
HEATSHOCKPROTEINBETA-1      MTERRVPFSLLRGPSW-----DPFRDWPYHSRLF--DQA-----FGLPRLPEEWSQW      45
HEATSHOCKPROTEINBETA-6      -----MEIPVPVQPSWLRASAPLGLSAPGRLF--DQR-----FGEGLLEAEALAA      46
ALPHA-CRYSTALLINBCHAIN      -----MDIAIHPWIRRRPFPF--FHSPSRLF--DQF-----FGEHLESDLPFT      48
ALPHA-CRYSTALLINCHAIN      -----MDVTIQHWPFKRTLGP--F-YPSRLF--DQF-----FGEGLFEYDLPF      39
  
```

```

HEATSHOCKPROTEINBETA-9      CPS-----VGLAERNRVAT-----MPV--LRLLDSPAQQEDNDHARDGFMK      57
HEATSHOCKPROTEINBETA-7      -----MFSDDFGSFMRPHSEP-----LAFPARPGGAGNIKTLGDAYEFA      85
HEATSHOCKPROTEINBETA-3      -----DHALYALPGPT--IVDLR--KTRAAQSPVVDAAETPPREGKSHFQIL      74
HEATSHOCKPROTEINBETA-8      WPDNALRLSSAMGPTLRSGMVRP-----GPTA-TARFGVPAAGTSPFPFGPKVVC      99
HEATSHOCKPROTEINBETA-2      -P-----TLYHGYYVPPRAAP-----AGEGSRAGASRLSEGGFQAF      97
HEATSHOCKPROTEINBETA-1      LG-----GSSMPGYRPLPAAAEISPAVAAPAYSRLSRQLSSGVSEIRHTADRMVR      98
HEATSHOCKPROTEINBETA-6      CP-----TTLAPYYLR-----PSV-----ALPVAQVTPDGHFSVL      77
ALPHA-CRYSTALLINBCHAIN      ST-----SLSPFL-RR-----PSFLR-APSWHFLDSEMRLEKQFVSN      78
ALPHA-CRYSTALLINCHAIN      LS-----STISPHY-RQ-----SLF--RTVDSGISEVSRDRDKVFIF      74
  
```

```

HEATSHOCKPROTEINBETA-9      LDAHGFAPEELVVQDQGLMVTGQQQLDVRDPERVSYRMSQVKHRLMPLSMTAMTC      117
HEATSHOCKPROTEINBETA-7      VDVRDQSPEDIIVTTSNNHIEVRA--EKLAADG--TVMNTFAHKCOLPEDVPTSVTS      139
HEATSHOCKPROTEINBETA-3      LDVVQFLPEDIIQTFFGMLLKAQHGTRDMEHG--FISRSFTRQYKLPDGVIEKDL      131
HEATSHOCKPROTEINBETA-8      VNVHSFKPEELMKTKDGVYVSGVSGHEEQDEGG--IVSKNFTKKIQLPAEDVPVTVFA      156
HEATSHOCKPROTEINBETA-2      LDVSHFTPDEVTVRTVDNLLVESARHPQLDRHG--FVSRFCRTQYVLPADVDPNVR      134
HEATSHOCKPROTEINBETA-1      LDVNHFAPELTVKTKDGVVEITGKHEERQDEHG--YISRCFTKTYLTPGVDPTQSS      155
HEATSHOCKPROTEINBETA-6      LDVKHFSPEEIAVKVVGHEVHARHEPRDEHG--FVAREFHRRYRLPGVDPAVTS      143
ALPHA-CRYSTALLINBCHAIN      LDVKHFSPEELKVKVGLGVIEVHGKHEERQDEHG--FISREFHRRYRIPADVDPLTIS      135
ALPHA-CRYSTALLINCHAIN      LDVKHFSPEELTVKVDQDFVIEVHGKHEERQDDEHG--YISREFHRRYRLPSNDQASL      131
  
```

```

HEATSHOCKPROTEINBETA-9      CLTPSGQLWVRGQCVALLPEAQTPG-----SPRLGSLGSKASNLTR-----      159
HEATSHOCKPROTEINBETA-7      ALREDGSLTIARRHPHTEHVQQTFRTEIKI-----      170
HEATSHOCKPROTEINBETA-3      VLCHDGLVVEVQDPVGTG-----      150
HEATSHOCKPROTEINBETA-8      SLSPEGLLIEAPQVPVPTGFGESSFNELPQDSQE-----VTCT-----      196
HEATSHOCKPROTEINBETA-2      ALSHOGILNLEAPRGGRHLDETVN--EYVLSLLPA-----PPDPEEEEEAAIVP      182
HEATSHOCKPROTEINBETA-1      SLSPEGTLVEAPMKLAT--QSN--EITPVTFSRAQLGGPEAAKSDETAAM--      205
HEATSHOCKPROTEINBETA-6      ALSPEGVLISQAAPASQAAPPAA--AK--      160
ALPHA-CRYSTALLINBCHAIN      SLSGSGVLTVNGPRKQV--SGP--ERTIPITREKPAVTAAPK--      175
ALPHA-CRYSTALLINCHAIN      SLSADGMLTFCGPKIQTGLDATHA--ERAIPVSREEKPTAPSS--      173
  
```

```

Alpha-crystallinBchain: M-DIAIH-HP-WIRR-PFFPF--HS-PSRLFDQFFGHEHLES-D-LFP-TSTLSLSPFYLRP--P---S-F
Alpha-crystallinAchain: M-DVTIQ-HP-WFKR-TLGP--Y--PSRLFDQFFGEGLEFYD-LLPFLSSSTISPHY-R---Q---S-L
Heatshockproteinbeta-6: M-EIPVPVQPSWLR--ASAPLPLGSAPGRLDQRFEGGLEAE--LAALCPTTLAPYYLR--P---S--
Heatshockproteinbeta-2: M-S-GRS-V-HP--ATAEYF-FANPSRLGEORFEGGLPEE-IL--TPTLYHGYVVR--P---R-A
Heatshockproteinbeta-1: MTERRVPFSL-LRGP-SWDPRDWPYHSRLFDQAGFLPRLPEE--WSQWLGSSWPGVYRPLPPAAIESPA
Heatshockproteinbeta-8: MADGQMPFSCHYPSRLRRDPFRDPLSSRLLDGFGMDPFPDGLTASW-PDWALP-RLSSAWPGTLRSGM
Heatshockproteinbeta-7: M-SHRTS-ST-F--R-AERSFHSSSSSSSSSSSSASRALPAQ-DPP-MEKALSMFSDDF--G---S-F
Heatshockproteinbeta-3: M-A-KI--I--LRHL-IEIPVR-Y--QEFEARGLEDCLRDHA-LYA-LPGPTIV-DLRK--T---R-A
Heatshockproteinbeta-9: M-Q-RVG-NT-FSNE-SR--V-----ASRC-PS-VG--LAERN--R--VAT-M-P--VR-----L
  
```

```

Alpha-crystallinBchain: LRAP--S-W-FD--T-GLSEMRLEKDRF--VNLDVKHFSPEELKVKVLGDVIEVHGKHE--RQDEH-GF-
Alpha-crystallinAchain: FR---T-V-LD--S-GISEVSRDRDKF--IFLDVKHFSPEELTVKVKQDDFVEIHGKHN--EQDDH-GY-
Heatshockproteinbeta-6: V-----A--L--P--VAQVPTDPGHF--VNLDVKHFSPEEIAVKVVGHEVHARHE--RPDEH-GF-
Heatshockproteinbeta-2: APAG--E-G-SR--A-GASELRLSEGGF--VLDVSHFTPDEVTVRTVDNLLVESARHP--QLDRH-GF-
Heatshockproteinbeta-1: VAAPAYSRLSRQLSSGVSEIRHTADRMVSLDVNHFAPELTVKTKDGVVEITGKHE--RQDDH-GY-
Heatshockproteinbeta-8: VPRGPTATARFGVPAEGRTPPPPFGPEKVKCVNVHFSKPEELMKTKDGVYVSGKHE--EQQEG-GI-
Heatshockproteinbeta-7: MRPHSEPLA-FPARPGGAGNIKTLGDAYEFAVDVRDPSPEIDIIVTTSNNHIEVRA---E-KLAAD-GT-
Heatshockproteinbeta-3: AQSP--P-V-DS--A-AETPPREGKSHFQILLDVVQFLPEDIITQTFEGWLLKAQHG-T-RMDEH-GF-
Heatshockproteinbeta-9: LR-D--S---P--A-AQEDNDHARDGFMKLDAGHFAPEELVVQDQGLMVTGQQQLDVRDPERVSYR
  
```

```

Alpha-crystallinBchain: ISREFHRRKYRIPADVDPPLTITSSSLSSDGLTVVGRPKQ--VSG--PE-R-T-IPITR-EE-KPAV-TAA-
Alpha-crystallinAchain: ISREFHRRYRLPSNVQDSALSCSLADGMLTFCGPKIQTGLDATHAE-R-A-IPVSR-EE-KP--TSA-
Heatshockproteinbeta-6: VAREFHRRYRLPPGVDPAAVTSALSPEGVLSI-----Q-----A-----PASA-QA-PP--PAA-
Heatshockproteinbeta-2: VSREFCRTYVLPADVDPNVRRAALSHDGLNLLEAPRGGRHLDETVNEVYISLLPAPP-DP-EEEE-EAAI
Heatshockproteinbeta-1: ISRCFTRKYTLPPGVDPDTQVSSSLPEGLTLVEAP-MP-KLATQSNIEITPVTFSRAQLGGPEAAKSDE
Heatshockproteinbeta-8: VSKNFTKILQPAEDVPVTVFASLSPGELLIEAPQVP-PYST-FGE-S--SF--NN-EL--PQ--DSQE
Heatshockproteinbeta-7: VMNTFAHKQLPEDVPTSVTSALREDGSLTIARRHP-H--T---E-H---V---Q-QT--F---RTE-
Heatshockproteinbeta-3: ISRSFTRQYKLPDGVIEKDLSAVLCHDGLLVV-----E-----V---K-D---P---VG-
Heatshockproteinbeta-9: MSQKVHRKM-LPSNLSPMTAMTCLTPSGQLWVRGQCV--LAL--PEAQ-T-GPSRLGS-LGS--KASN
  
```

```

Alpha-crystallinBchain: PK-K
Alpha-crystallinAchain: PS-S
Heatshockproteinbeta-6: -A-K
Heatshockproteinbeta-2: VE-P
Heatshockproteinbeta-1: TAAK
Heatshockproteinbeta-8: VTCT
Heatshockproteinbeta-7: IK-I
Heatshockproteinbeta-3: -T-K
Heatshockproteinbeta-9: LT-R
  
```

[illegible]

- 36

Résultats : Comparaison

CLUSTAL O(1.2.4) MULTIPLE SEQUENCE ALIGNMENT	
HEATSHOCKPROTEINBETA-9NQ-----RVGNTFSNESR-----VASR
HEATSHOCKPROTEINBETA-7	MSHTT-----SSTF---RAEFSHSSSSSSSSSSSASRALPAQDPMEKALS--
HEATSHOCKPROTEINBETA-3	MAKILLNHLT-----EIPVYQ---EEF-----EAEGLDECK---
HEATSHOCKPROTEINBETA-8	NAGQWPFSCRP--SRL--RQDFRDSLSLL---DQG-----VGDHPDQLTAS
HEATSHOCKPROTEINBETA-2	MSGSVMAHP-----ATAEYFANPSQLF---EQD-----FEGGLPEELTL
HEATSHOCKPROTEINBETA-1	NTERVFFSLRGPSS---DPFRDYNHSILF---DQA-----FGLRLPEEKQW
HEATSHOCKPROTEINBETA-6	---NEIPVPQPSMLRRASAPLGLSARILF---DQR-----FEGGLLEAAL
ALPHA-CRYSTALLINCHAIN	---MDIAIHWMIRPPFP---FHSRILF---DQF-----FGEHLLESDLPFT
ALPHA-CRYSTALLINCHAIN	---MDVIQHWPKRITLGP---FVPSILF---DQF-----FGEGLFEYDLFP
HEATSHOCKPROTEINBETA-9	CPS-----VGLAEIRNVAT-----MPV---DLLRDSAPAQENDHARDGFQK
HEATSHOCKPROTEINBETA-7	---HFSDFGSPMRHSEP-----LAFPARPGAGNKLTDGAYEFA
HEATSHOCKPROTEINBETA-3	-----DHAYALPGPT--IVDLR---KTAAGSPVDSAAETPRGKSHFQIL
HEATSHOCKPROTEINBETA-8	WPMALPRLSSAMFGLRSGVRP-----QPTA-TAIFGVPAEGRTPPPFGEPMKVC
HEATSHOCKPROTEINBETA-2	---P-----TLHYGYVVPAAAP-----AGESSAGASELSEGIGQAF
HEATSHOCKPROTEINBETA-1	LG-----GSDPWPVIRPAAEPAVAPAAVPSMLSRQLSSGSEIHTADNRVY
ALPHA-CRYSTALLINCHAIN	CP-----TTLAPYLLA-----PSV---ALPVAQVPTDQWISVL
ALPHA-CRYSTALLINCHAIN	ST-----SLSPYL--RP-----PSFLR-APSWFDTGLSEMILKDFSVN
ALPHA-CRYSTALLINCHAIN	LS-----STISPY--RQ-----SLF---RTVLDGISEVSDDDKVFVF
HEATSHOCKPROTEINBETA-9	LDANGFAPEELVQVQGGKLVYTGQQLDVQDFEIVSYRSQVHKMLPSNLSPMTAC
HEATSHOCKPROTEINBETA-7	VGVQVDFPEDIIVTSSNNIVEA---ELALAG---TYNFAFKQLPQDVDTITS
HEATSHOCKPROTEINBETA-3	LDVQVDFPEIDIQTFGALLTAQDCTMDHG---FTSRSTQVQLPDQVEXLSA
HEATSHOCKPROTEINBETA-8	VWHSFPEELMWKTKDGYVESSGHEEQGSG---VYSKNTDKIQLPAEVPVTFPA
HEATSHOCKPROTEINBETA-2	LDVSHFTPDQVTVRTVNLVLSARHPQLDQHG---FVSRFCRTYVLPADVPKWIVA
HEATSHOCKPROTEINBETA-1	LDVSHFPADELVTKTGQVETTGQHEEQDQHG---VYSIRCFRTYVLPQGVDTQVSS
HEATSHOCKPROTEINBETA-6	LDVSHFSPEEIAVYVGVGEVHAEHAEKPDHG---FVAREFHRVYLPQVDPAAVTS
ALPHA-CRYSTALLINCHAIN	LDVSHFSPEELVYVGLDVTEVHGHEEQDQHG---FTSRFHRVYLPQVDPDLTTS
ALPHA-CRYSTALLINCHAIN	LDVSHFPEELTVYQVQDFVEIGHGHEEQDQHG---FTSRFHRVYLPQVDSGLSC
HEATSHOCKPROTEINBETA-9	CLTPSGQWQGVQVALPEAQTP-----SPRLGSLGKASNLTR-----
HEATSHOCKPROTEINBETA-7	ALVDEGSLTIRARRPHTEHVQV--TFRTETK-----
HEATSHOCKPROTEINBETA-3	VLCOGILLVVEVPDVK-----
HEATSHOCKPROTEINBETA-8	SLSPGELLTAPQVPPVYTFSGSPNMLPQDQ-----VYCT-----
HEATSHOCKPROTEINBETA-2	ALSHOGLNLNLAEPGGHGLATEVNL--EYVLSLPA-----PPDEEEEAALVEP
HEATSHOCKPROTEINBETA-1	SLSPGCTLYEAPMKPLAT--QSN--EITIPYTFESRAQLGGEAAKSDETAAK-----
HEATSHOCKPROTEINBETA-6	ALSPGVLTSQAAPASQAAPPAA--AK-----
ALPHA-CRYSTALLINCHAIN	SLSDGVLTVNPGKQV---SGP--EETPTTREETKPAVTAAPKK-----
ALPHA-CRYSTALLINCHAIN	SLSADGNLTFCGKIQTGLDATHA--EATVPSEETKPSAPSS-----
Alpha-crystallinBchain:	M DIAIH-NP-WIKR-PFFPF--HS-PSRLDQFFGEGHLLSD-LFP-TSTLSPEFYLRP--P----S-F
Alpha-crystallinAchain:	M DVTIQ-NP-WFKR-TLQPF--Y--PSRLDQFFGEGGLEFYD-LLPFLSSTISPYR--R--Q---S-L
Heatshockproteinbeta-6:	M EIVFPVQPSILRR-ASAPLPGLSAPGRFLDQRFGEGLLEAE-LAALCPTLAPVYLR--P----S-
Heatshockproteinbeta-2:	M S-GRS-VP-MHP-ATAEYE-FANPSRLGEQRFGEGLLEAE-TL--TPLYHGYVYR--P----R-A
Heatshockproteinbeta-1:	M EIRVPFSL-LRGP-SWDPFEDWYHSHRLDQAQGLRLRLEE-WSQWLGSSGMYRPLPAATESPA
Heatshockproteinbeta-8:	M DGMQPFSCYPSRLRRDPFRDPSLSRLLDDGFGDPDFDOLTASW-PWMLP-LRSSAMPTLRSGL
Heatshockproteinbeta-7:	M SHRTS-ST-F-R-AERSFHSSSSSSSSSSSSASRALPAQ-DPP-MEKALSMFSDDF--G----S-F
Heatshockproteinbeta-3:	M A-KI--I--LRHL-TEIPVR-Y--QEEFEARGLDCLRLDHA-LYA-LPGTIVT-DLRK--T---R-A
Heatshockproteinbeta-9:	M Q-RVG-NT-FSNE-SR--V-----ASRC-PS-VG--LAERN--R--VAT-M-P--VR-----L
Alpha-crystallinBchain:	LRAP--S-W-FD--T-GLSEMRLEKDRF--VNLDVKHFSPEELKVKVLGDVIEVHGKHE--RDEPF-GF-
Alpha-crystallinAchain:	FR---T-V-LD--S-GISEVRSDRDKRF--IFLDVKHFSPEELTVKVKVQDDFVEIHGKHE--RDEPF-GY-
Heatshockproteinbeta-6:	V----A--L--L--P--VAQVPTDQGHF--VLDVKHFSPEELIAVKVVGHEVHAEHAE--RDEPF-GF-
Heatshockproteinbeta-2:	APAG--E-G-SR--A-GASELRLSEGKFA-----TVRTVQNLVLSARHP--KLDRI--GF-
Heatshockproteinbeta-1:	VAAAPYSAALRQLSSGSEIHTADNRVYLDVSHFPADELVTKTGQVETTGQHEEQGSG--KQEG--GY-
Heatshockproteinbeta-8:	VVRGPTATARFGVPAEGRTPPPFGEPMKVCNVHVSFKPEELMWKTKDGYVESSGHE--KQEG--GI-
Heatshockproteinbeta-7:	MRHSEPLA-FPARPGAGNKLTDGAYEFAVDVDFSPEDIIVTSSNNHIVEA---E-KLAD--GT-
Heatshockproteinbeta-3:	AOSP--P-V-DS--A-AETPPREGKSHFOILLDVQVLPEDIIVTTFEGWLLIAQHG--T-RMDEH-GF-
Heatshockproteinbeta-9:	LR-D-S----P-A-AQENDHARDGFQMKLDAHGAPEELVQVQDQWLVMTGQQV--RDPERSVRY
Alpha-crystallinBchain:	ISREFHRRYRIPADVPLTITSSLSDDGLTV--GPRKQ--VSG--PE-R-T-IPTR-EE-KPAV-TAA-
Alpha-crystallinAchain:	ISREFHRRYRLPSNVDSGLSCSLSDAGMLTF--GPKIQTGLDATHAE-R-A-IPVSR-EE-KP---TAA-
Heatshockproteinbeta-6:	VAREFHRRYRLPGVDPAVAITSALSPGVLST----Q---A-----A--PASA-QA-PP---PASA-
Heatshockproteinbeta-2:	VSRFCRTYVLPADVQPMVRAALSHDGLNLAPRGRHLDETVNEVYISLIPAPP-DP-EEEE-EAAT
Heatshockproteinbeta-1:	ISRCFTKYVLPQGVDTQVSSLSPEGLTAP-MP-KLATOSMETIIPVTFESRAQLGGEAAKSDE
Heatshockproteinbeta-8:	VSKNKTQIQLPAEVPDVTYFASLSPGELLTAPQV-PYST-FGE-S--SF-INL-EL--PQ--DQEG
Heatshockproteinbeta-7:	VNMTFAHKQLPEDVQDPTYSALRDEGLTIVARRHP-H-T---E-H---V---Q-OT-F--RTE-
Heatshockproteinbeta-3:	ISRSFTQYKLPDGEVTKLSAVLCHDGLVW-----E-----E-----K-D--P--P--VG-
Heatshockproteinbeta-9:	MSQKVHRKM-LPSNLSPTAMCCLTSPGQWLWQGVCA--LAL--PEAQ-T-GPSRLGS-LGS--KASN
Alpha-crystallinBchain:	PK-K
Alpha-crystallinAchain:	PS-S
Heatshockproteinbeta-6:	A-K
Heatshockproteinbeta-2:	VE-P
Heatshockproteinbeta-1:	TAAK
Heatshockproteinbeta-8:	VTC
Heatshockproteinbeta-7:	IK-I
Heatshockproteinbeta-3:	T-K
Heatshockproteinbeta-9:	LT-R

- Arbre guide différent
- Modèle de Markov caché

Résultats : Comparaison

CLUSTAL O(1.2.4) MULTIPLE SEQUENCE ALIGNMENT		
HEATSHOCKPROTEINBETA-9NQ-----RVGNTFSNESR-----VASR	17
HEATSHOCKPROTEINBETA-7	MSHIT-----SSTF---RAEFSHSSSSSSSSSSASRALPAQDPEKALS--	36
HEATSHOCKPROTEINBETA-3	MAKILLHLLT-----EIPVYQ---EEF-----EAELEDCR---	40
HEATSHOCKPROTEINBETA-8	HALQWPFSCRP--SRL--RQDFRDSLSELL---DQF-----VGHQPPDQLTAS	47
HEATSHOCKPROTEINBETA-2	MSGVVHMP-----ATAEYFANPSLLG---EQD-----FEGGLPEELTL	44
HEATSHOCKPROTEINBETA-1	NTERVFFSLRGPSS---DPFRDVIYSHLFS---DQA-----FGLRLPEEKQW	45
HEATSHOCKPROTEINBETA-6	---NEIPVQVPSMLRRASAPGLSAPGLF---DQR-----FEGGLEALAL	45
ALPHA-CRYSTALLINCHAIN	---MDIAIHMMIRDPFFP---FHSPIRLF---DQF-----FGEHLESDLPFT	40
ALPHA-CRYSTALLINCHAIN	---MDVIQHFWKRTLGP---F-VYPSILF---DQF-----FGEGLFVYDLFP	39
:		
HEATSHOCKPROTEINBETA-9	CPS-----VGLAEIRNVAT-----MPV---DLLRDSAPQEDNDHARDGFQK	57
HEATSHOCKPROTEINBETA-7	---HFSDFGSPMRHSEP-----LAFPARPGAGNKLTDGAYEFA	85
HEATSHOCKPROTEINBETA-3	---DHAYALPGPT--IVDLR---KTAAGSPVDSAAETPRGKSHFQIL	74
HEATSHOCKPROTEINBETA-8	WPMALPRLSSAMFGLRQVPR-----QPTA-TAIFGVPAEGRTPPPFGEPMKVC	99
HEATSHOCKPROTEINBETA-2	---P-----TLHYGVYVPAAP-----AGESSAGASELSEGQPAF	77
HEATSHOCKPROTEINBETA-1	LG-----GSDPQVVPRLPAALZEPAAVPAVPSRLSQSSGSEIDHADRVS	98
ALPHA-CRYSTALLINCHAIN	CP-----TTLAPYLLA-----PSV---ALPVAQVPTDQHWVSL	77
ALPHA-CRYSTALLINCHAIN	ST-----SLSPYL-RP-----PSFLR-APSWFDTGLSEMILKDFSVN	78
ALPHA-CRYSTALLINCHAIN	LS-----STISPY-RQ-----SLF---RTVLDGISEVSDDDKVFVF	74
:		
HEATSHOCKPROTEINBETA-9	LDANGFAPEELVQVQGGKLVYTGQQLDVQDFEIVSYRSQVHKMLPSNLPTAMTC	117
HEATSHOCKPROTEINBETA-7	VGVQVQPEEIIITSNENIVEA---ELALAG---TYMVFANKQLPQVDQITDTS	139
HEATSHOCKPROTEINBETA-3	LDVQVQPEIDIQTTEGALLTAQDCTMDHG---FTSRFTQYQLVDQETDLASA	131
HEATSHOCKPROTEINBETA-8	VWHSFPEELMWKTKDGYVEGSHQEEQDGG---VYSKNTFKIQLPAEVPVTFPA	156
HEATSHOCKPROTEINBETA-2	LDVSHFTPEDEVTVTDNLLEVASRHPQLDGHG---FVSRFCRTYVLPADVPQWVA	134
HEATSHOCKPROTEINBETA-1	LDVSHFPADELVTKTDGVEITGQHEEQDGHG---VYSRFCRTYVLPQVDQVSS	155
HEATSHOCKPROTEINBETA-6	LDVSHFSPEEIAVYVGVGEVHARHEEPDGHG---FVAREFHRVYLPQVDPAAVTS	134
ALPHA-CRYSTALLINCHAIN	LDVSHFSPEELVYVQVQDVEYHGHHEEQDGHG---FTSRFHRVYLPQVDPDLTTS	135
ALPHA-CRYSTALLINCHAIN	LDVSHFSPEELTVYQVQDVEYHGHHEEQDGHG---FTSRFHRVYLPQVQDGLSC	131
:: *::: : : : :		
HEATSHOCKPROTEINBETA-9	CLTPSGQWQVQCVALLPEAQGTQ-----SPRLGSLGKASNLTR-----	159
HEATSHOCKPROTEINBETA-7	ALVDEGSLTIRARRPHTEHVQQ--TFRTETK-----	170
HEATSHOCKPROTEINBETA-3	VLCOGILLVVEVPDVKTC-----	150
HEATSHOCKPROTEINBETA-8	SLSPGELLTEAPQVVPYTFSGSPNMLPQDGE-----VYCT-----	196
HEATSHOCKPROTEINBETA-2	ALSHOGLNLLEAPGGHGLDTEVN--EYVSLPAA-----PPDEEEEAALVEP	182
HEATSHOCKPROTEINBETA-1	SLSPGCTVTEAPMKPLAT--QSN--EITIPYTFESRAQGLGEAAKSDETAAK--	205
HEATSHOCKPROTEINBETA-6	ALSPGVLSTQAPASQAAPPPAA--AK-----	160
ALPHA-CRYSTALLINCHAIN	SLSDGDLTVNPGKQV---SGP--EETPTITREEKPAVTAAPKK--	175
ALPHA-CRYSTALLINCHAIN	SLSADGNLTFQCGKIQTGLDATHA--EATVPSFEKPTSPASS-----	173
* . * . *		
Alpha-crystallinBchain: M DIAIH-HP-WIKR-PFFPF--HS-PSRLFDQFFGEHLLSD-LFP-TSTLSPEFYLRP--P---S-F		
Alpha-crystallinAchain: M DVTIQ-HP-WFKR-TLQPF--Y-PSRLFDQFFGEGLFEYD-LLPFLSSTISPYR--Q---S-L		
Heatshockproteinbeta-6: M EIPVVPQVPSMLRR-ASAPLGPLSAPGLRFDQFGEGLLEAE-LAALCPTLAPVYLR--P---S-A		
Heatshockproteinbeta-2: M S-GRS-VP-MHP-ATAEYE-FANPSRLGEQFGEGLLE-IL--TPYLVGVYVR--P---R-R		
Heatshockproteinbeta-1: M HGRVPFSL-LRGP-SWDPFEDRWYHSLRDLQAAGELRLREE-WSQWLGSSNPGYVRLPAAETESA		
Heatshockproteinbeta-8: M DGMQPFSPCHYPSRLRRDPFRDPSLSRLDDGFGDPDFDOLTASW-PNALP-LRSSAMPTLRSGL		
Heatshockproteinbeta-7: M SHRTS-ST-F-R-AERSFHSSSSSSSSSSTSSASRALPAQ-DPP-MEKALSMFSDDF--G---S-F		
Heatshockproteinbeta-3: M A-KI--I--LRHL-TEIPVR-Y--QEEFEARGLEDCLDHA-LYA-LPGTPTV-DLRK--T---R-A		
Heatshockproteinbeta-9: M Q-RVG-NT-FSNE-SR--V----ASRC-PS-VG--LAERN--R--VAT-M-P--VR-----L		
Alpha-crystallinBchain: LRAP--S-W-FD--T-GLSEMRLEKDRF--VNLDVKHFSPEELKVKVLGDVIEVHGKHE--RDEPF-GF-		
Alpha-crystallinAchain: FR---T-V-LD--S-GISEVRSRDRKF--IFLDVKHFSPEELTVKVKVQDDFVEIHGKHE--RDEPF-GY-		
Heatshockproteinbeta-6: V----A--L--L--P--VAQVPTDQGHF--VLDVKHFSPEELIAVKVGVGEVHARHE--RDEPF-GF-		
Heatshockproteinbeta-2: APAG--E-G-SR--A-GASELRLSEGKFA-----TVRTVDNLLEVASRHP--KLDRI--GF-		
Heatshockproteinbeta-1: VAAPAYSRALRQLSSGVSEIRHTADRWVSLDWNHFAPEELTKTKDGYVEYTGKHE--RDEPF-GY-		
Heatshockproteinbeta-8: VVRGPTATARGVPAEGRTPPPFGEPMKVCNVHVSFKPEELMWKTKDGYVEYTGKHE--KQEEG-GI-		
Heatshockproteinbeta-7: MRHPSEPLA-FPARPGAGNKLTDGAYEFAVDVDFSPEDIIITVTSNNHIVERA---E-KLAAD-GT-		
Heatshockproteinbeta-3: AOSP--P-V-DS--A-AETPPREGKSHFOILLDVQVLPEDIIITQTFEGWLLIAQHG--T-RMDEH-GF-		
Heatshockproteinbeta-9: LR-D-S----P-A-AQEDNDHARDGFQMKLDAHGAPEELVQVQDQWLVMTGQQ--RDPERSVYR		
Alpha-crystallinBchain: ISREFHRRYRIPADVPLTIITSSLSDDGLTV--GPRKQ--VSG--PE-R-T-IPTR-EE-KPAV-TAA-		
Alpha-crystallinAchain: ISREFHRRYRLPSNVQDGLSCSLSDAGMLTF--GPKIQTGLDATHAE-R-A-IPVSR-EE-KP---TAA-		
Heatshockproteinbeta-6: VAREFHRRYRLPGVDPAVTSALSPEGVLT-----Q---A-----A--PASA-QA-PP---PASA-		
Heatshockproteinbeta-2: VSRFCRTYVLPADVQVPMVRAALSHDGLNLAPRGRLHLDTEVNEVYISLLPAPP-DP-EEEE-EAAT		
Heatshockproteinbeta-1: ISRCFTKTYVLPQVDQVTSLSPEGLTAP-HP-KLATOSMETIIPVTFESRAQGLGEAAKSD		
Heatshockproteinbeta-8: VSKNMTFKIQLPAEVPVTFVASFSLPEGLTTEAPQV-PYST-FGE-S--SF-INL-EL--PQ--DQEG		
Heatshockproteinbeta-7: VVNTFAHKQLPEDVQDPTVSALRDEGLT--ARRHP-H-T---E-H---V---Q-OT-F--RTE-		
Heatshockproteinbeta-3: ISRSFTROYKLPDGEIKDLASLVCHDGLVW-----E-----E---K-D--P---VSG-		
Heatshockproteinbeta-9: MSQKVHRKM-LPSNLSPTAMCCLTSPGQWLWGCQVA--LAL--PEAQ-T-GPSRLGS-LGS--KASN		
Alpha-crystallinBchain: PK-K		
Alpha-crystallinAchain: PS-S		
Heatshockproteinbeta-6: A-K		
Heatshockproteinbeta-2: VE-P		
Heatshockproteinbeta-1: TAAK		
Heatshockproteinbeta-8: VTC		
Heatshockproteinbeta-7: IK-I		
Heatshockproteinbeta-3: T-K		
Heatshockproteinbeta-9: LT-R		

- Arbre guide différent
- Modèle de Markov caché
- pénalité de gap constante

Conclusion



- Trois étapes implémentées

Conclusion



- Trois étapes implémentées



- Complexité temporelle

Conclusion



- Trois étapes implémentées



- Complexité temporelle



- Des résultats satisfaisants