



Antibody Characterization Using Next Generation Sequencing made easier with **Group My Abs** shiny app

Volha Tryputsen | Johnson & Johnson

R in Pharma | 15 August, 2018

Raise you hand if you are a Lego fan!



Lego Mess



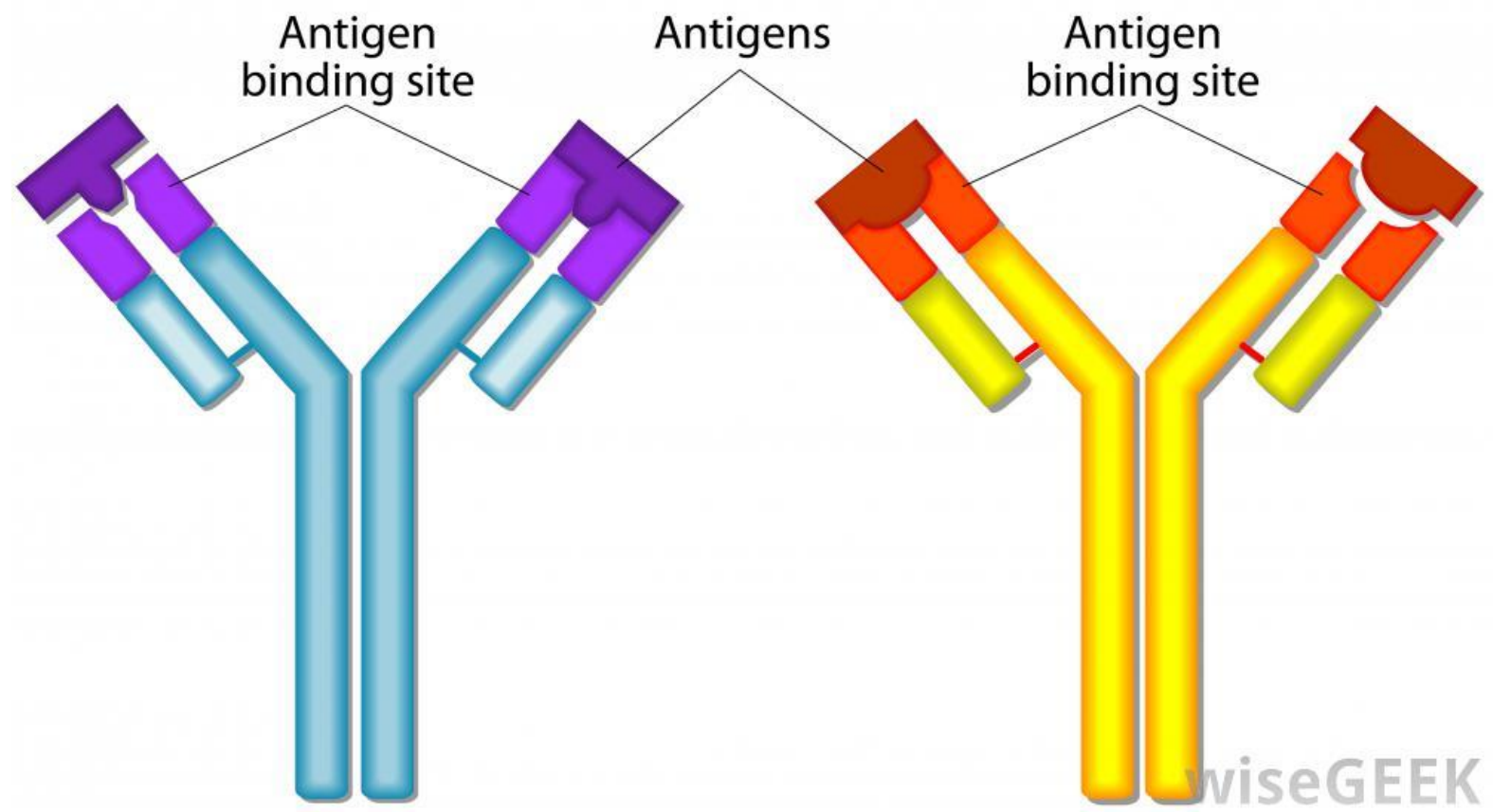
Lego Sorting



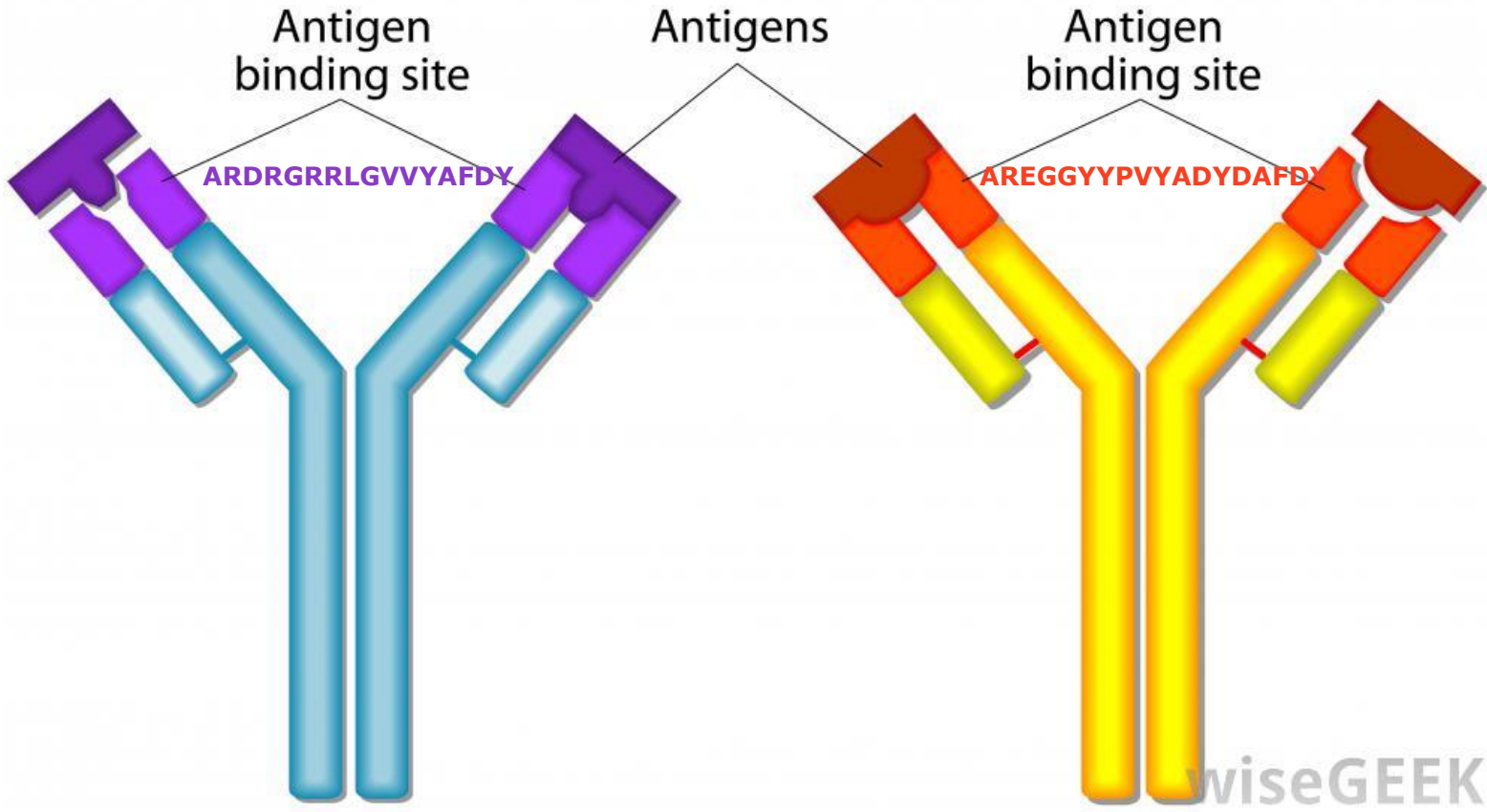
Large molecule drug discovery: High-throughput screening results

ARHPAFNPAFDY	AKVGWVGSYELDY	ARDSYEYGRSNAFDY	ARGRGGLAGAFDY	ARDGGGSGWNYRGGYFDY	ARVSLGVAFAFY	ARDERYFDY	ARERSYYWLGSYGAFDY	ARHYLSGSLGLDY
AKASGKGLDY	ARPKFDYGVGHFDY	ARVMNRFAYSHLDY	ARGTAIFDY	ARDLSGNSLDPAFDY	ARGFGYRFDY	AREATYGDYFDY	AKDGNVVCNNYYLDY	ARKKPGDHRADLDY
ARDTRSVDGFDY	ARQLWGLDY	ARGRSPRYFDY	AKLAGRTL	ARLADLFDY	ARGLGNSVARAFDY	ARFSPGSYGGLDY	AKKSNWFDY	ARPRRWLDY
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ARDRGRRLGVVYAFDY	ARHDPWSLGLDY	ARLARWTFRLDY	AKNSHYSALRFDY	ARVSRFTDGLDY	ARDCNVLDY	ARMMWDSFDN	ARGERRSLYMFYD	ARYGSSFDY
AKRTRLDY	ARDRGYGNLYRSYLYYFDY	ARNTSYLDY	ARHTPFSGCYCLDY	ARDCLTSVWFDY	ARDSLTASSFAFY	ARWRRELDY	ARNAGGDDYYLDY	ARYRSRFDY
ARVHYRQVWLDY	ARDRYGWSRYPVYFAY	ARHSWRTYHWELDY	ARTRGPAVPFDY	ARERYRWRSYGSYFYD	ARGSLSGFDY	VRDAGGDDYYLDY	ARRCEWALDY	ARASRSYDGFY
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ARERYRYGRYGSYFYD	ARDPGGSYRGAYGFDY	ARDLYLDY	AKKHNLWLDY	ARLQLLFPDY	ARGGGGWLTGTYFYD	ARGESDTSGSFDY	ARDGGCEEAFLDY	ARDRRYRGLDY
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AKRRRDSRSRLDY	ARVRDRFAYSMLDY	ARTSVGETFDY	ARVSRVEFDY	ARGRNTGSFDY	ARVDPWSHLDY	ARDTAPGPGEDLDY	ARGCCGRTLDY	ARVYFSRFDY
	ARGRGRYGRGYFDY	ARGRYRWVRVGRYSYFYD	ARDAGGDDY	ARTVLGLDY	ARDAGGDDYYLG	ARECPITNGYSTFDY	ARHDWSSYSWYLDY	ARWDTDAKYGRFDY

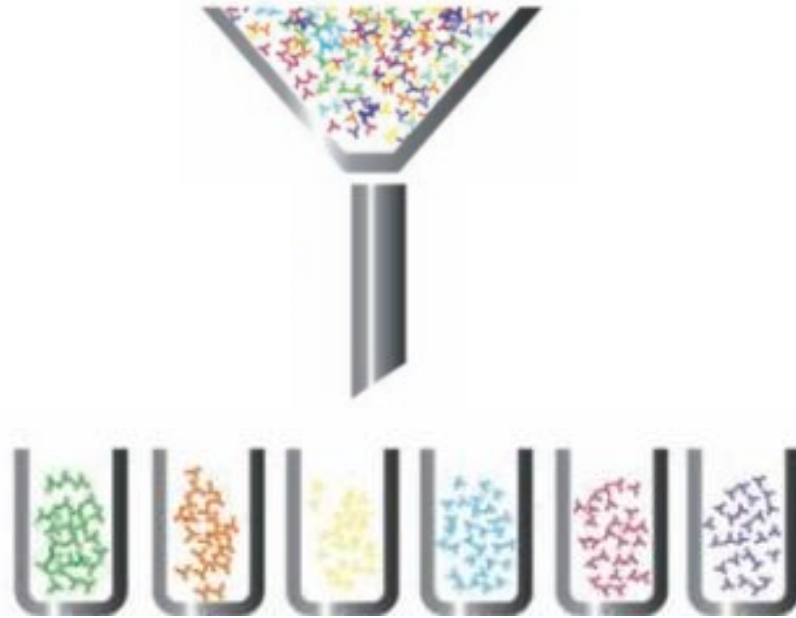
Antibody binding



Antibody binding



Classifying antibodies



Classifying antibodies by a shape of a binding site



Group My Abs Shiny App

1. Upload data

Browse...

NGSAnalysisDynSub-v2.1-BTLACHO_vs

Upload complete

2. Select your variable for analysis:

Amino.Acid.CDR3

3. Clean the data:

- ☐
- ☐ Iso-Asp
- ☐ Trp
- ☐ N-link ,Deamidation site
- ☐ Met
- ☐ Iso-Asp ,Trp
- ☐ N-link
- ☐ Deamidation site
- ☐ Iso-Asp ,N-link ,Deamidation site

MSA Interactive

Clustal family arrangement

Documentation

Import

Sorting

Filter

Selection

Vis.elements

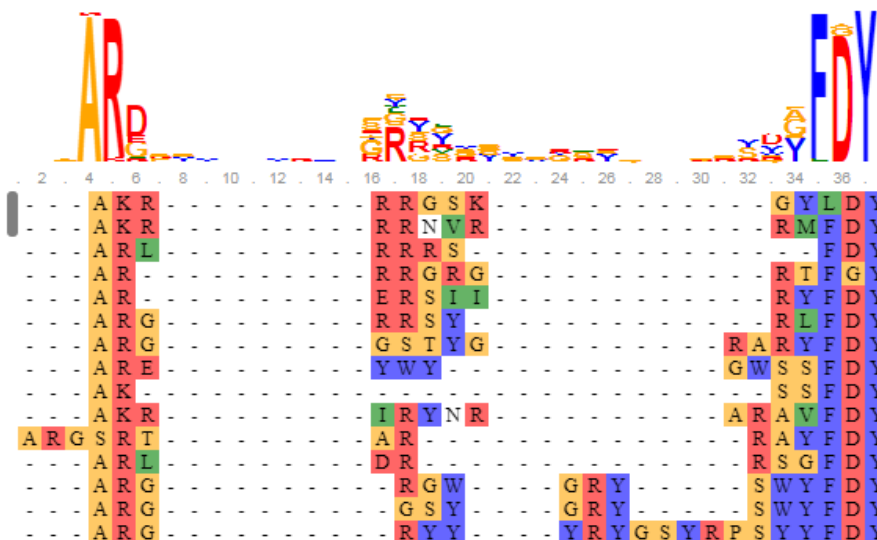
Color scheme

Extras

Export

Help


ID Label
1 8
2 35
3 20
4 57
5 116
6 46
7 102
8 28
9 51
10 17
11 84
12 86
13 78
14 105
15 18



Steps in antibody classification

1. Make sequences **comparable**
2. Evaluate **differences** between the sequences
3. Classify sequences into **families**

1. Make sequences comparable

ARGRTVGYFDY	
ARDLGDYRDYAFDY	
ARDSRSYDGFDY	
ARGRRVGYFDY	
.....	
ARGLGGFDY	
ARETRSYDGFDY	
AKRRRGSKGYLDY	
ARGRYRVPTSFDY	

100`s of sequences

1. Make sequences comparable

ARGRTVGYFDY

ARDLGDYRDYAFDY

ARDSRSYDGFY

ARGRRVGYFDY

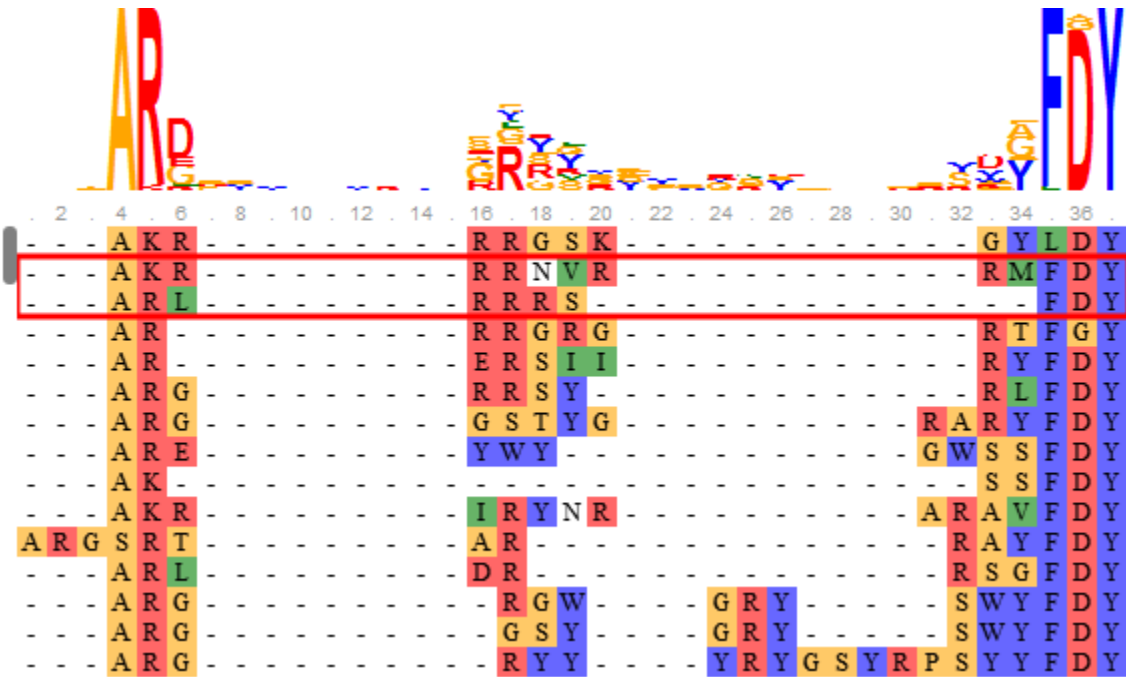
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ARGLGGFDY

ARETRSVDGFY

AKRRRGSKGYLDY

ARGRYRVPTSFDY



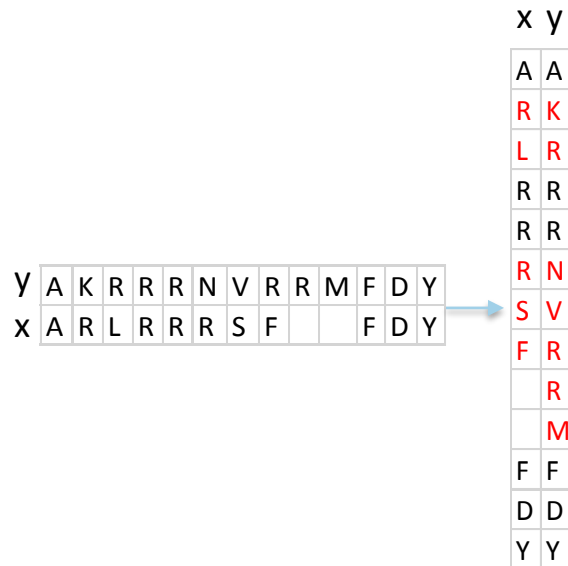
100` s of sequences

Dynamic Multiple Sequence Alignment with ClustalW

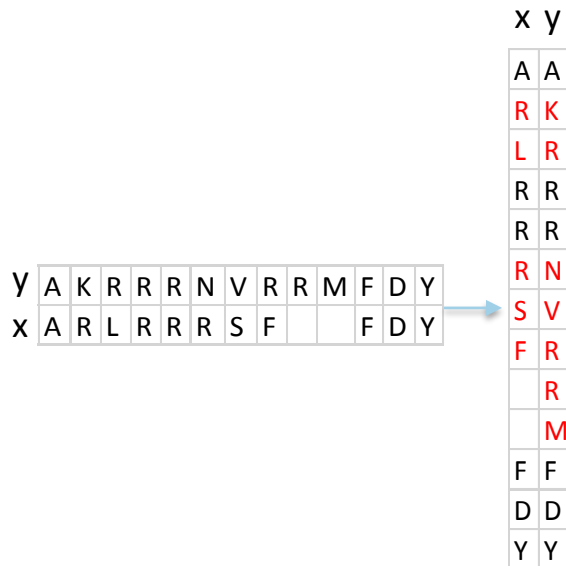
2. Difference between two sequences

Y	A	K	R	R	R	N	V	R	R	M	F	D	Y
X	A	R	L	R	R	R	S	F			F	D	Y

2. Difference between two sequences

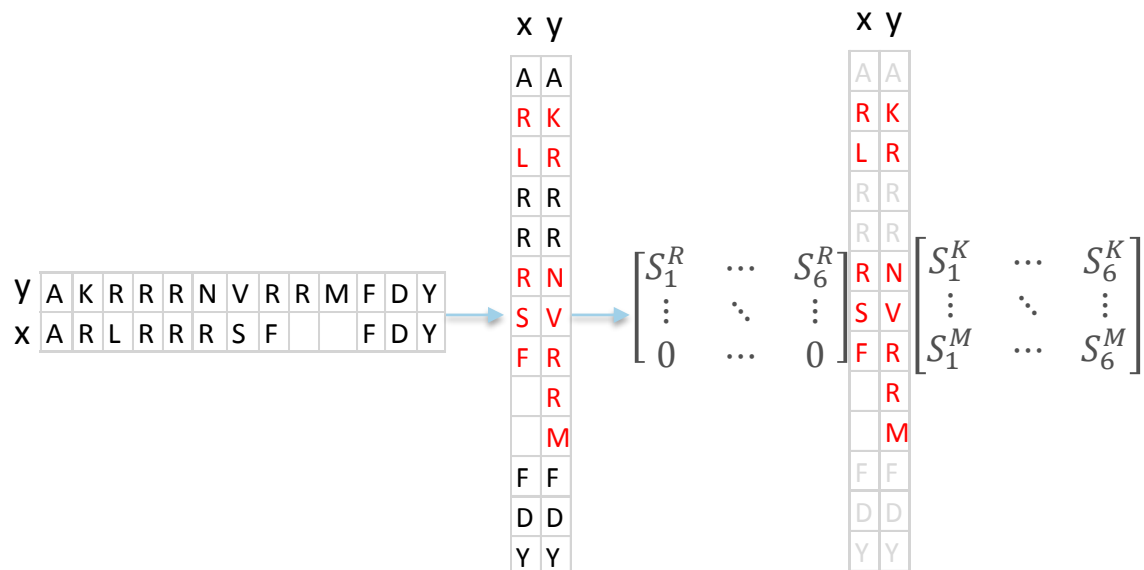


2. Difference between two sequences



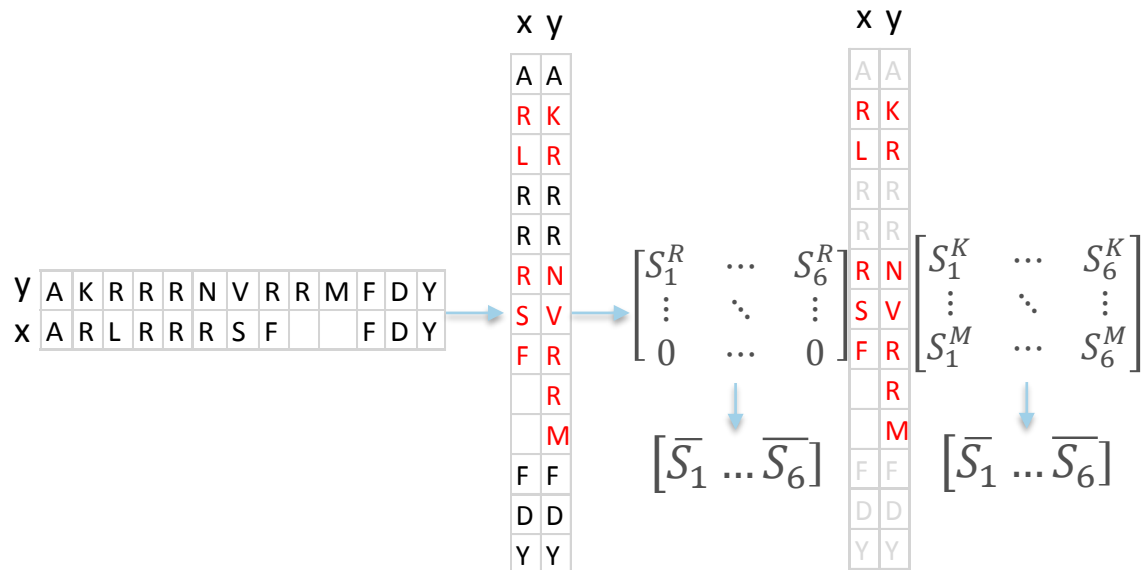
Amino acid	Hydrophobicity at pH 7 ⁽¹⁾	Hydrophilicity scale ⁽²⁾	Avg side chain orientation angle scale ⁽²⁾	Polarity scale ⁽²⁾	H bond donors ⁽²⁾	pI ⁽³⁾
A	41	0.28	0.51	0.00	0.17	6.00
R	-14	1.00	0.37	1.00	0.73	10.76
N	-28	0.66	0.12	0.07	0.39	5.41
D	-55	0.79	0.14	0.96	0.30	2.77
C	49	0.07	0.91	0.03	0.31	5.07
Q	-10	0.65	0.02	0.07	0.53	5.65

2. Difference between two sequences



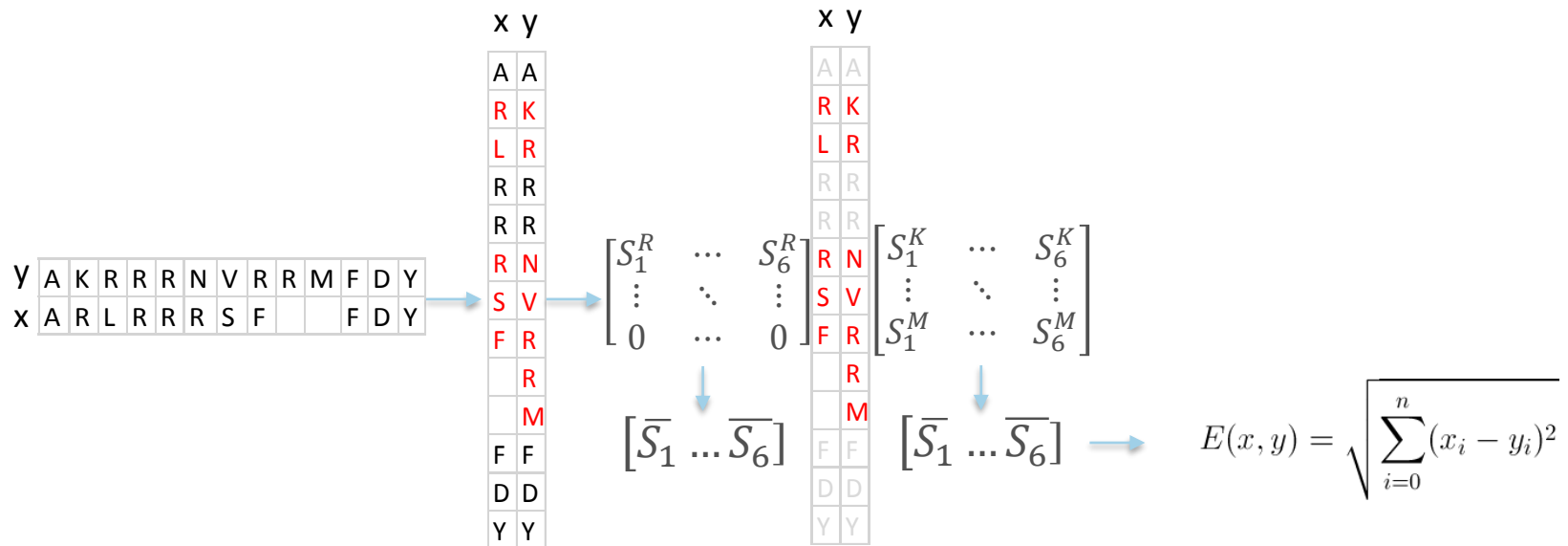
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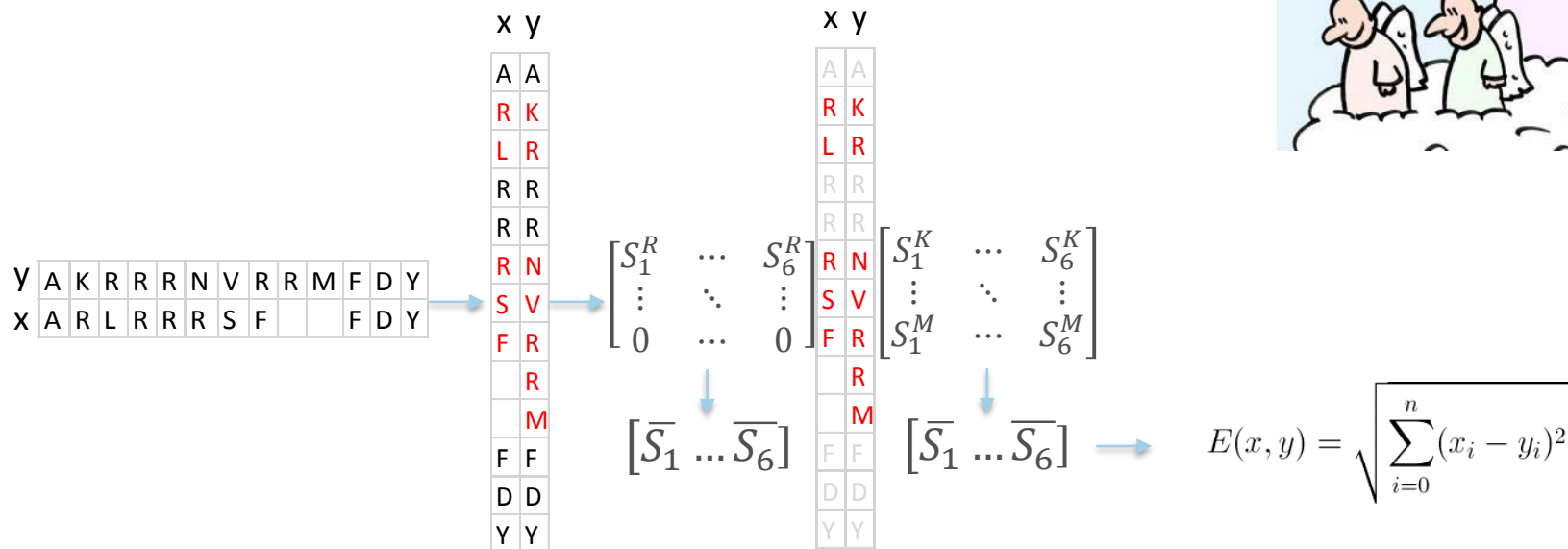
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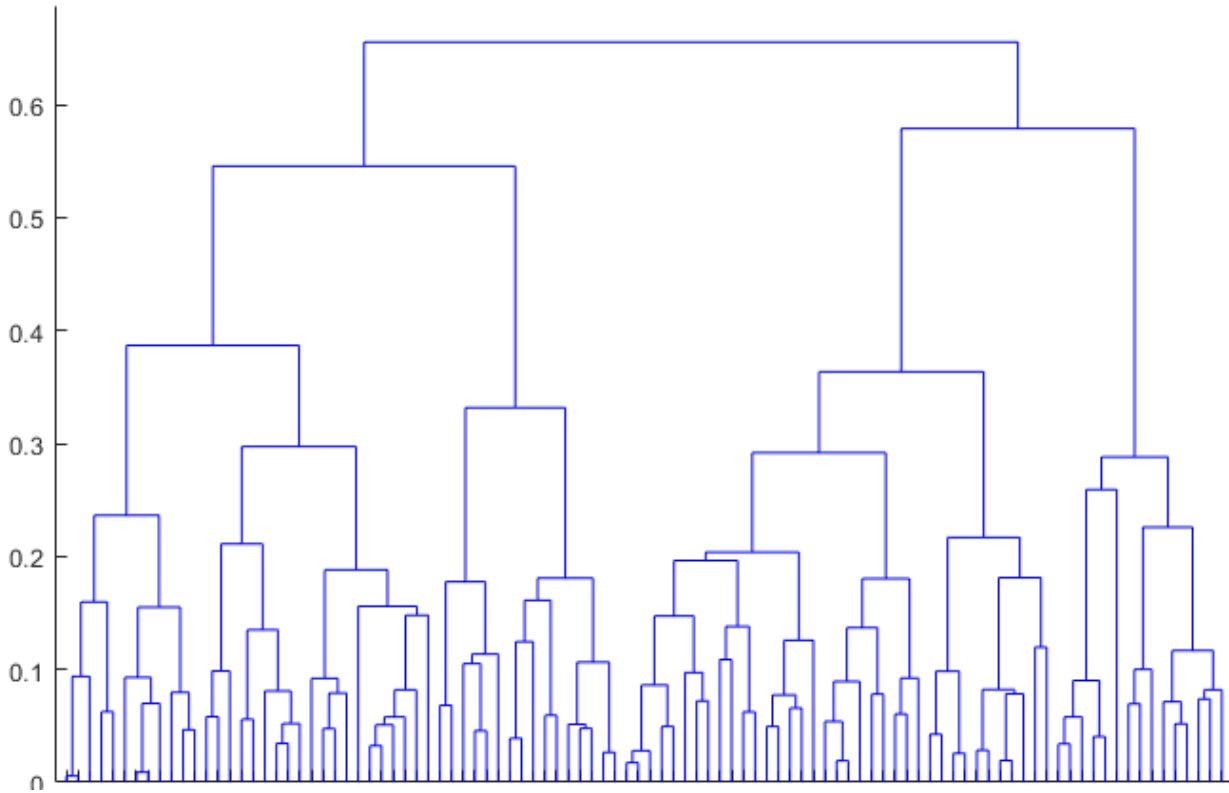
2. Difference between two sequences

"It's amazing what they can do with amino acids these days"



Amino acid	Hydrophobicity at pH 7 ⁽¹⁾	Hydrophilicity scale ⁽²⁾	Avg side chain orientation angle scale ⁽²⁾	Polarity scale ⁽²⁾	H bond donors ⁽²⁾	pI ⁽³⁾
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C	49	0.07	0.91	0.03	0.31	5.07
Q	-10	0.65	0.02	0.07	0.53	5.65

3. Classify sequences into families:
How many families **do you think** are there?



3. Classify sequences into families:

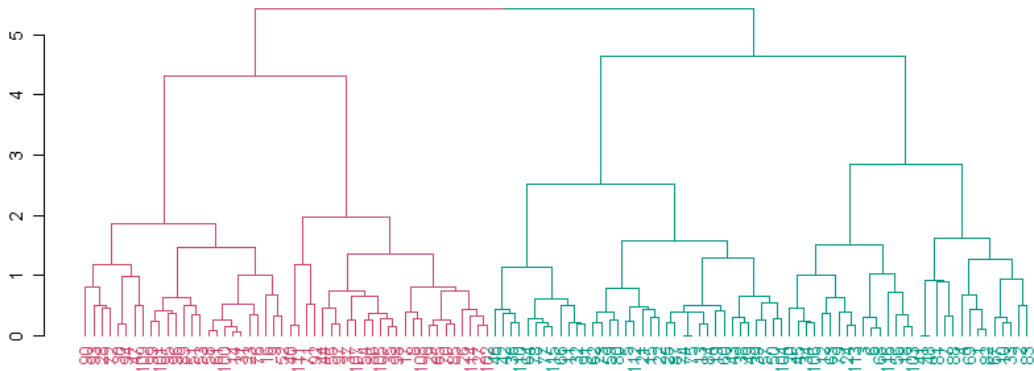
Group My Abs, how many families are there?

Suggested number of clusters:

Method	N_Clusters
frey	2.00
mcclain	2.00
cindex	2.00
silhouette	2.00
dunn	15.00

Choose the number of clusters:

2



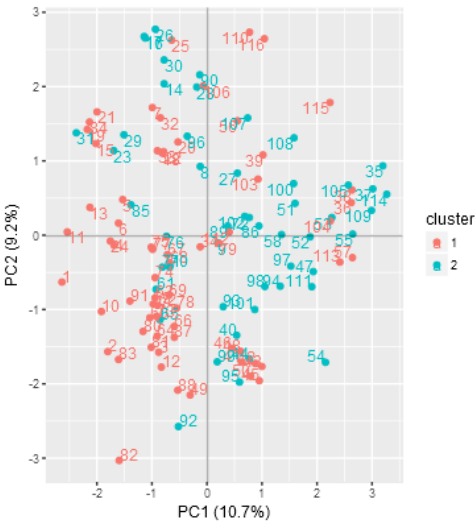
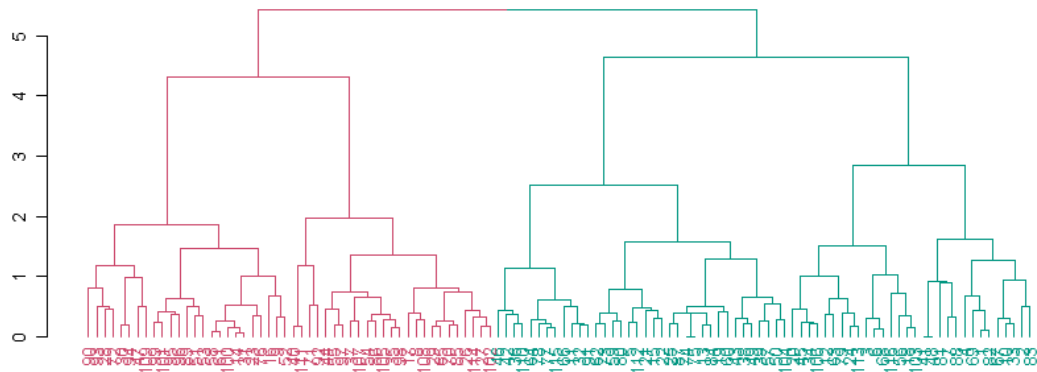
3. Classify sequences into families: Optimal number of clusters

Suggested number of clusters:

Method	N_Clusters
frey	2.00
mcclain	2.00
cindex	2.00
silhouette	2.00
dunn	15.00

Choose the number of clusters:

2



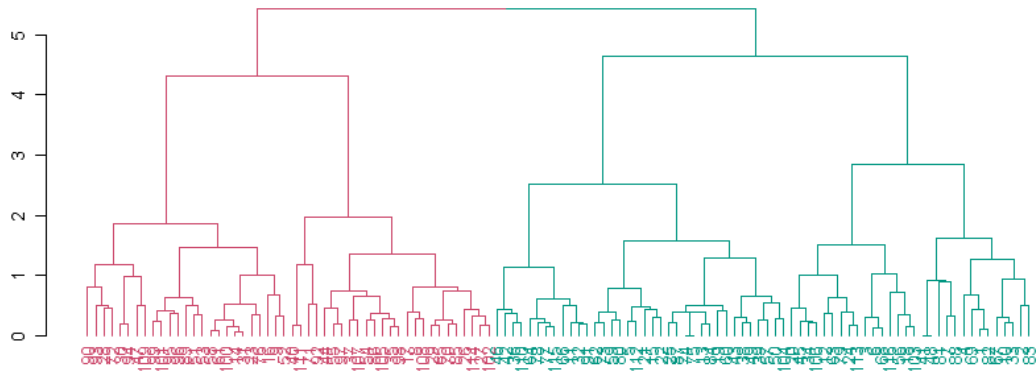
3. Classify sequences into families: Visualize families with a dendrogram

Suggested number of clusters:

Method	N_Clusters
frey	2.00
mcclain	2.00
cindex	2.00
silhouette	2.00
dunn	15.00

Choose the number of clusters:

2



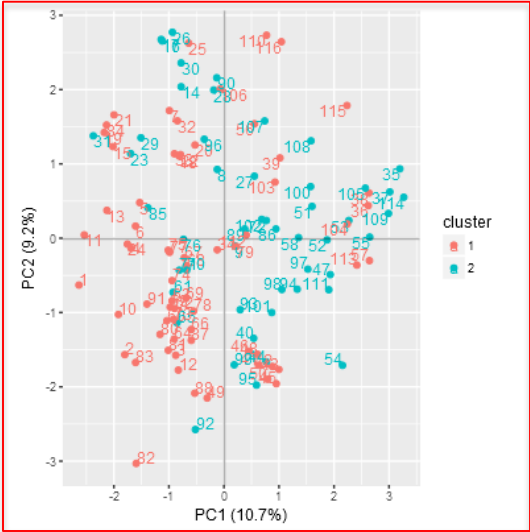
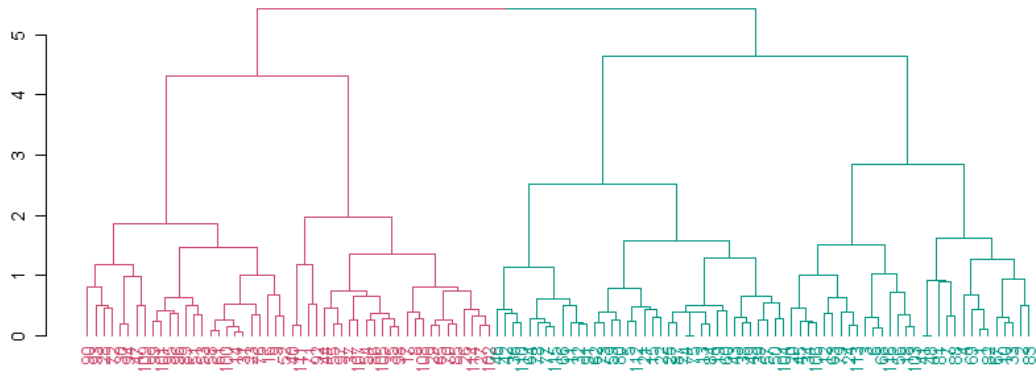
3. Classify sequences into families: Visualize families with MDS

Suggested number of clusters:

Method	N_Clusters
frey	2.00
mcclain	2.00
cindex	2.00
silhouette	2.00
dunn	15.00

Choose the number of clusters:

2



Antibody Characterization Using Next Generation Sequencing

ARHPAFNPAFDY	AKVGWVGSYELDY	ARDSYEYGRSNAFDY	ARGRGGLAGAFDY	ARDGGGSGWNYRGGYFDY	ARVSLGVAFAFY	ARDERYFDY	ARERSYYWLGSYGAFDY	ARHYLSGLGLDY
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ARDGGRQGFY	AKQFRNSYSDPFYDY	AREGGYYPVADYDAFDY	ARGAGDDYYLDY	AKDGGDYWGDFDY	ARDDAGPYLFDY	ARGRYSTRFDY	ARRHIVFDY	ARYLIRFDY
ARGLYPWYSYGSYFFDY	ARHRRGAFFDY	AKHVSTFRGNLDY	ARGYRRTIFYGY	ARGPYGYVNWIGDYFDY	ARVKRHSYGSFDY	ARGRSYDGFY	AKHNARGEFDY	AKAAGNCAHGFFDY
AKNSGKGFY	ARQYVDASDGGDLDY	ARGHRSDVYTYLDY	ARGSSSGPTCYCRFDY	ARGRRNIDSRGFDY	ARVPSPWARFDY	ARGVMRMGYSGLDY	ARAPGSTIYFDY	AKHRVRAFVFDY
AKNAWGWFGAELDY	ARIIWSTYLGSDY	ARGRRGGTGGFDY	ARGEAFGTCLDY	ARARGIVNWFDY	ARVTRRLDY	ARIAYSFSSFDY	ARGVTSLPLFDY	ARDAGGDDYYLDC
ARDSITSDGFDY	ARDTSFRLRYRFDY	ARDAGGDDYYFDY	ARLPRKFDY	ARGRRVGLFDY	AKPMNCLCLDY	ARKIDEREFSGLDY	ARARRLGWFDY	ARDAGGDDYYLDY
AREYLDSEGFY	ARGYDFFAYNALDY	ARIAAGFAYNALDY	ARDPDGYYSRFGFDY	ARGFSYVFDY	ARDNAPVLDY	ARNDSYFALDY	ARDGTSSSRYAFDY	ARDVGGDDYYLDY
AKASGRAFDY	ARERYLLRRRGYGYFFDY	AKSDGGSRLGLDY	ARGDPWWGDFDY	ARGRRNVYFDY	ARDRLWGGYRAFDY	ARNIWLVLVDY	ARDRRQYGGLDY	ARDWEAFRYKHLRDY
ARIDSPYDCCGYLDY	ARVPWHVSKLDY	ARGSGCIDGLDY	ARVQVFPLDY	ARGRYYPWRSYGSYFFDY	ARGRRSYRLFDY	ARRTEVLDY	ARGGSRADLYGYLYY	AREYSYGAGDAFDY
ARTYGYAGVSLDY	ARDTRGYDGFY	ARRRNGSYFAY	ARDWVYSAHLDY	ARSIRGGFDY	ARHWISRLDY	ARVGYYNVNWFYDY	ARGTPYGGLDY	ARGAYGYWFDY
AKESRTADGFDY	AREPSSYPWNNNGASSYDAFDY	AREASDGFY	ARGRGGGSTFDY	AKVDRDGRWAGLDY	ARMCEELDY	ARVWSHMVIPLFYLDY	ARNRMLLDY	ARGRYYPWRVRGYSYFFDY
AKRMRGSKRYLDY	ARGRGYGLRGFDY	ARVFSHGWSGLDY	ARDSLTYDGFY	ARGAYVDDWFDY	ARVGEYVSFDY	ACDAGGDDYYLDY	ARTWVYLDY	ARHCFAFDY
ARVDPWSLDLDY	ARSRPSSFYDY	ARDRYYGGNSVRRGGYFFDY	ARDRRGKAGLDY	ARRRPWSGFLDY	ARVSWDGVFFDY	ARDEGNFATLDY	ARVSSRARFDY	ARLMALLDY
AKAAAGRALDY	AREQRTYDGFY	ARGOGGFAYSCLDY	ARDSVTSDFY	TRPYSLDY	ARDAGGDGYLDY	ARDMGNSLSGYGLDY	ARVSSWAGFDY	ARLRNGFDY
ARDPARGRSRGFDY	AKEDRQYDGFY	ARHIWGYDFYGLDY	ARGVYWGHSGLDY	AKHLHGLDY	ARGIDRGKCCQCLDY	ARDYNLGNNDALDY	AKDIWKWHFDY	ARSVGDWFDY
AKSVRIFDY	ARENPNNGDFY	AKCRINLWDYDPGFY	ARQFMMMLDY	ARDVPITQLDY	ARGRVGTFDY	ARGLSGYLLGRRYGYFDY	AKGFNARLDY	ARVDPWSTDFDY
AKGWGFSGSGLDY	ARHWRGKYYWIFGLDY	AKKHVWFDY	ARVRIWGWVRVGSYFFDY	ARGRSYEATANLDY	ARLWASFYDY	ARGLTWLDY	ARDYVDVNDYFDY	ARVSSWARFGY
AKGSKALFDY	AKGGYAGCCNDFY	ARDTAGCWTFDY	ARAARIGTFDY	ARRAAWIGSFDY	ARPGRITLTDY	ARHDCKYKHLDY	ARGACGHGLDY	ARDEGGYKFDY
ARDGRTSDGFDY	AKPYLWLDY	ARHTWGYDAYGLDY	ARVDDWYRTFDY	ARVSSWARLDY	ARRGWPLDY	ARKLYALLDY	ARGCAGESLDY	ARDSATYDGFY
ARDTRSSDGFY	ARVDPWSWDFY	ARDARTSDGFY	AREYYSGDGFY	AREPSWPGNGAGAFDY	ARVDDHDYILKLDY	ARQSVCLDY	ARGFGSSSLRAFDY	ARDY
AKMGKVFDY	ARGRYRWVSYGSYFFDY	ARGQADSFY	ARGDPWSMDLDY	ARGRVGSLGFFYDY	ARASDTGSLDY	TRDAGGDDYYLDY	ARGRTALVFDY	ARERAAALDY
AKSSGKAFDY	ARISGWADDRFDY	ARGRGGGLWGFDY	ARGRGAYLIWFYFDY	ARDAGGDDYYSDY	ARDEYEGSAWYFDY	AKHSWGWAGDLDY	ARLSRRLDY	ARERYDSYGVVDAFDY
ARDGYGAKHYVLAFDY	ARDPYGGEVNTQRYGMDY	ARIDPWSLDLDY	ARGWYPGYRGDLDY	ARVSPWARFDY	ARETMSLDY	ARARSDRWFLDY	ARQSWEFYDY	ARGCYLLCFDY
ARERYYWRRSYGYFFDY	ARDPDGSLAWGFDY	ARESGGTVSLSYYYGFDY	ARTWIAMVFFDY	ARIWVWGLGMPFDY	ARGRGAGRGFDY	ARDYVQVGGWLDY	ARRSWFTLPGSLDY	ARGGSVYVAFDY
ARQRSYKSALRYFDY	ARDTRAYDGFY	ARGSCCCLDY	AKHGDDTHVWDLDY	ARNSDGWASLDY	ARGRGNLRGFDY	ARERYRWVRVGSYFFDY	ARRSSRLDY	ARGISSDSFDY
ARGRGYFMANFDY	ARGRRVAFFDY	ARGQMVMFDY	ARGIDYAVDGFY	AKHCYCGVFDY	AKDQVGMYPVEYLDY	ARGNEDWADYWDLLDY	AKGHSAWKPLDY	ARGPDYISAFDY
ARENRTYDGFY	AKRGVGLRLDY	ARNNEEHLDY	ARHLDTGTAFFDY	AR	ARSNVLDY	AR	AKLIAWFCFEYLDY	ARLEAFCSYCYCFDY
ARVSPGPYGLFDY	AKGNAAGGFDY	ARALIASWFDY	ARDAGGDDY	ARNYGNTRDDFDY	ARAVSRFDY	ARDLYRGDGFY	ARAGFYVKVWGEFDY	ARNWYCYPSLDY
ARDSLTSDGFDY	ARDGQAYYAWYWLVDY	ARDTLTSDGFY	ARENRLDY	ARRPYIGHFDY	ARRHRYIHLELDY	ARDRRWFAGAFDY	ARDGGYRTDGTYYYFDY	ARGSGGNGSAHFDY
ARGDPWSVDFY	ARSISYPLYWLDY	ARPYKGLDY	ARRGSSNNSTFDY	AREASSASSDAFDY	ARMQSRFDY	ARDSSPYGYFDY	ARFSGQFLDY	ARVSSWARFN
AKRRRDSRSRLDY	ARVRDRFAYSMLDY	ARTSVGETFDY	ARVSRVEFDY	ARGRNTGSFDY	ARVDPWSHLDY	ARDTAPGPGEDLDY	ARGCCGRTLDY	ARVYFSRFDY
	ARGRGRYGRGYFDY	ARGRYRWVRVGSYFFDY	ARDAGGDDY	ARTVLGLDY	ARDAGGDDYYLY	ARECPITNGYSTFDY	ARHDWSSSYWLDY	ARWDTDAKYGRFDY

Antibody Characterization Using Next Generation Sequencing

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ARHPAFNPAFDY	AKVGWVGSYELDY	ARDSYEYGRSNAFDY	ARGRGGLAGAFDY	ARDGGGSGWNYRGGYFDY	ARVSLGVAFAFY	ARDERYFDY	ARERSYYWLGSYGAFDY	ARHYLSGLGLDY
AKASGKGLDY	ARPKFDYVGYHFDY	ARVMNRFAYSHLDY	ARGTAIFDY	ARDLSGSNLDPAFDY	ARGFGYFDY	AREATYGDYFDY	AKDGNVVCNMYLDY	ARKKPGDHRADLDY
ARDTRSYDGFY	ARQLWGLDY	ARGRSRPFYDY	AKLAGRTL	ARLADLFDY	ARGLGNSVARAFDY	ARFSPGSYGGLDY	AKKSNWFDY	ARPRRWLDY
AKRTKLLDY	ARISDDDFDY	ARGVTTLGRDDYFDY	ARDTRASDGFY	ARRAAWGGWADLDY	ARDAGGGDYLDY	ARGPCFSIGTPLDY	ARFGFSLDY	ARVQDGLYSFIDY
ARDRGRLGVVYAFDY	ARHDPWSLGLDY	ARLARWTFRLDY	AKNSHYSALRFDY	ARVSRFTDGLDY	ARDCNVLDY	ARMMWDSFDN	ARGERRSLYMFYDY	ARYGSSFDY
AKTRRLDY	ARDRGYGNLYRSYLYYFDY	ARNTSYLDY	ARHTPFGCYCLDY	ARDCLTSCVWFDY	ARDSLTASSFAFDY	ARWRRELDY	ARNAGGDDYLDY	ARYRSRFDY
ARVHYRQVWLDY	ARDRYGWSYPPVYFAY	ARHSWRTYHWEVDY	ARTRGPAVYFDY	ARERYRWRSYGSYFFDY	ARGSLSGFDY	VRDAGGDDYLDY	ARRCEWALDY	ARASRYDGFY
AKHQRPGLDY	AKLSPFPGWPFYDY	AREGGGSGAGSYDGFY	AKGVFSNLFDY	ARGRTLGYFDY	ARVHSVFFLDY	ARASSWARFDY	ARATVASGWVWFYDY	ARAVVPLDY
ARERYYRGYRGSYFFDY	ARDPGGSYRGAYGFDY	ARDLYLDY	AKKHNLWLDY	ARLQLLPFDY	ARGGGGWLTGTYFFDY	ARGESDTSGSFDY	ARDGGCEACLDY	ARDRRYRGLDY
AKHRRGSSLDY	ARVDPWSVDFDY	ARDRGPYFDY	AKKHTWFDY	ARRCYLDY	AKGSVSGDGFY	ARHCTDITNLVLDY	ARGGSRWRGAFDGFAY	ARFSPDADGGSFDY
ARVGRVSAGYFDY	ARGPSYPWLLYGYGGAFDY	ARGRYPPWVYGSYFFDY	ARRAAWVGDFDY	ARVAGWDLGKFDY	ARGSVCTIFCQSFYDY	ARNKDGCSFTLDY	ARGRDYRGGTAFDY	ARGRGGRLYDAFDY
ARGRYPPWYGYGSYFFDY	ARDSRASDGFY	ARDSRSVDGFDY	ARDRGIYGGFDY	ARVQFLPLDY	ARGTWIFDY	ARVAGFYMYQTYLDY	ARGRGRLGVVYAFDY	ARHVLSPGLDY
AKGAGASVAWDFDY	ARMRKAQFDY	AKIRGWRRADFDY	ARDRGRSSPGFDY	ARGGWTVGSPYAFDY	ARRDIQWPHNELDY	ARDAGGDDHYLDY	ARIQMLDY	ARVGGPAPWFDY
ARADPWSIDFDY	AKSSFYDY	ARGTGAYNWAHGFY	ARERSLNSYRGFDY	ARNIRATYFDY	ARRYAFGTALDY	ARETHSAFGDYAWLDY	ARLASVLDY	ARVLKWHLDY
ARDGGRQGGFDY	AKQFNYSNDPFDY	AREGGYPPVADYDAFDY	AKDGGDYVWDFDY	ARDDAAGPYLFDY	ARGGRYSRTFDY	ARRHIVFDY	ARVLIREFDY	ARDAGGDDYLDY
ARGLYPPWYSYGSYFFDY	ARHRRGAFDY	AKHVSTFRGNLDY	ARGYRRTIFYGY	ARGPYGYGNWIGDYFDY	ARKVRHSYGSFDY	ARGRSYDGFY	AKHNARGEFDY	AKAAGNCAHGFFDY
AKNSGKGFY	ARQYVYDASDGGDLDY	ARGHRSDDYTYLDY	ARGSSSGPTCYCRFDY	ARGCRNIDSRGFDY	ARVPSWARFDY	ARGVMRRCYSGLDY	ARAPGSTIFYDY	AKHRVRAFVFDY
AKNAWGWFGAELDY	ARIWWSYTLGSFDY	ARGRRGGTGGFDY	ARGEAFGTCTFDY	ARARGIVNWFDY	ARVTRRLDY	ARIAYSFSSFDY	ARGVTGSLPFDY	ARDAGGDDYLDY
ARDSITSDGFDY	ARDTSFRLRYRFDY	ARDAGGDDYFDY	ARLPRKFDY	ARGRRVGLFDY	AKPMNCLCLDY	ARKIDEREFYSGLDY	ARARRLGWFDY	ARDAGGDDYLDY
AREYLDSEGFY	ARDGYFAVNALDY	ARIAAGFAYNALDY	ARDPDGYYSRFGFDY	ARDNAPYFDY	ARDNAPYFDY	ARNDSYFALDY	ARDGTSSSRYAFDY	ARDVGGDDYLDY
AKASGRAFDY	AREYLLGRRGYGYFFDY	AKSDGSGRGLLDY	ARGDPWWGDFDY	ARGRRNVYFDY	ARDRLWGGYAFDY	ARNIWLWLDY	ARDRRQYGGLDY	ARDWEAFRYKHLRDY
ARIDSPYDCCGYLDY	ARVPWWSKLDY	ARGSGCIDGLDY	ARVQFVPLDY	ARGRYPPWRSYGSYFFDY	ARGRRSYRLFDY	ARRTEVLDY	ARGGSRADLYGYLYY	AREYSYGAGDAFDY
ARTYGYAGVSLDY	ARDTRGYDGFY	ARRRNGSYFAY	ARDWVYSALDY	ARSIRGGFDY	ARHWISRLDY	ARVGVYNWVNFYDY	ARGTPYGGLDY	ARGAYGYWFDY
AKESRTADGFDY	AREPSSYPWNNAGASSYDAFDY	AREASDGFY	ARGRGGGSTFDY	AKVDRDRGWAGLDY	ARMCEELDY	ARVWSHMMVPLFYLDY	ARNRMLLDY	ARGRYPPWRVRGYSYFFDY
AKRMRGSKRYLDY	ARGRGYGLRGFDY	ARVFSHGWSGLDY	ARDSLTYDGFY	ARGAYVDDWFDY	ARVGEYVSFDY	ACDAGGDDYLDY	ARTWVYLDY	ARHCFAFDY
ARVDPWSLGLDY	ARSRPSSVFDY	ARDRYYGGNSVRRGGYFFDY	ARDRRGKAGLDY	ARRRPVSGFLDY	ARVSWDGVFFDY	ARDEGNFATLDY	ARVSSRARFDY	ARLMALLDY
AKAAAGRALDY	AREQRTYDGFY	ARGOGGFAYSCLDY	ARDSVTSDGFY	TRPYSLDY	ARDAGGDYLDY	ARDMGNSLSYGLDY	ARVSSWAGFDY	ARLRNGFDY
ARDPARGRSRGFDY	AKEDRQYDGFY	ARHIWGYDFPYGLDY	ARGVYVGHGSLDY	AKHLHGSLDY	ARGIDRGKCCQCLDY	ARDYNLGNDAELDY	AKDIWKWHFDY	ARVSGDWFDY
AKSVRIFDY	ARENPNNGDFY	AKCRINLWYDYPGFDY	ARQFMMLDY	ARDVPITQLDY	ARGRVGTFDY	ARGLSYLLGRRYGYFDY	AKGFNARLDY	ARVDPWSTDFDY
AKGWGFSGGLDY	ARHWWRGKYWSIFGLDY	AKKHVWFDY	ARVRIYGWVRVRYGSYFFDY	ARGRSYEATNLDY	ARLWASFDY	ARGLTWLDY	ARDYVDVNDYFDY	ARVSSWARFGY
AKGSKALFDY	AKGGYAGCCNDFDY	ARDTAGCWTFDY	ARAARIGTFDY	ARRAAWIGSFDY	ARPGRITLTDY	ARHDCKYKHLDY	ARGACGHGLDY	ARDEGGYKFDY
ARDGRTSDGFDY	AKPYLWLDY	ARHTWGYYDAYGLDY	ARVDDWYRTFDY	ARVSSWARLDY	ARRGWPLDY	ARKLYALLDY	ARGCAGESLDY	ARDSATYDGFY
ARDTRSSDGFY	ARVDPWSWDFDY	ARDARTSDGFDY	AREYYSGDGFY	AREPSWPGNGAGAFDY	ARVDDHDYILKLDY	ARQSVCLDY	ARGFGSSSLRAFDY	ARDY
AKMGKVFDY	ARGRYRWVVSYSYFFDY	ARGQADSFY	ARGDPWSMDLDY	ARGRVGSLGFFDY	ARASDTGSLDY	TRDAGGDDYLDY	ARGRTALVFDY	ARERAAALDY
AKSSGKAFDY	ARISGWADDRFDY	ARGRGGGLWGFYDY	ARGRGAYLIWFDYFDY	ARDAGGDDYSDY	ARDEYEGSAWYFDY	AKHSWGWAGDLDY	ARLSRRLDY	ARERYYSYGVVDAFDY
ARDGYGAKHYVLAFDY	ARDPYGGEVNTQRYGMDV	ARIDPWSGLDY	ARGWYPGYRGDLDY	ARVSPWARFDY	ARETMSLDY	ARARSDRWFLDY	ARQSWFFDY	ARGCYLLCFDY
ARERYRWRSYGYFFDY	ARDPDGSLAWGFDY	ARESGTVSLSYYYGFDY	ARTWIAMVFFDY	ARIWVWGLGMPFDY	ARGRGAGRGFDY	ARDYVQVGGWLDY	ARRSWFTLPGSLDY	ARGGSSVYVAFDY
ARGRSYSALRYFDY	ARDTRAYDGFY	ARGSCCCLDY	AKHGHTVHWDLDY	ARNSDGWASLDY	ARGGNSLRGFDY	ARERYRWVRVRYGSYLDY	ARRSSRLDY	ARGISSDSFDY
ARGRGYFMANFDY	ARGRRVAFDY	ARQMVMFDY	ARGIDYAVDGFY	AKHCYCGVFDY	AKDQVGMYPVEYLDY	ARGNEDWADYWDLLDY	AKGHSWAKPLDY	ARGPDYISAFDY
ARENRTYDGFY	ARGRTNDGFY	AKRGVGLRLDY	ARNNEHLDY	ARHLDTGAFFDY	AR	ARSNVLDY	AKLIWFCFEYLDY	ARLEAFCSYCYCFDY
ARVSPGPYGLFDY	AKGNRAAGGFDY	ARALIASWFDY	ARDAGGDDY	ARNYGNTRDDFDY	ARAVSRFDY	ARDLYRGDGFY	ARAGFYVWVGEFDY	ARNWYYPYSLDY
ARDSLTSDGFDY	ARDGQAYYAWYWLWLDY	ARDTLTSDGFDY	ARENRLDY	ARRPWIGHFDY	ARRHRYHLELDY	ARDRRWFAGAFDY	ARDGGYRTDGTYYYFDY	ARGSGGNSAHFDY
ARGDPWSVDFDY	ARSYIPYLWLDY	ARPYKGLDY	ARRGSSNNSTFDY	AREASSASSDAFDY	ARMQSRTFDY	ARDSSPYGFDY	ARFSGQLDY	ARVSSWARFN
AKRRRDSRSRLDY	ARVRDRFAYSMLDY	ARTSVGETFDY	ARVSRVEFDY	ARGRNTGSFDY	ARVDPWSHLDY	ARDTAPGPGEDLDY	ARGCCGRTLDY	ARVYFSRFDY
	ARGRGYRGRYFDY	ARGRYRWVRVRYGSYFFDY	ARDAGGDDY	ARTVLGLDY	ARDAGGDDYLYG	ARECPITNGYSTFDY	ARDHWSYSSWYLDY	ARWDTDAKYGRFDY

Getting closer to discovering new antibody treatments



Thank you!

Mark Tornetta

Jocelyn Sendeki

Bill Pikounis

Paulo Bargo

Satish Murphy