



# “How to use IEDB in your research”

## Examples on Orthopox

Presented by: Alba Grifoni, PhD, Instructor/Research Faculty

La Jolla  
Institute  
FOR IMMUNOLOGY

Life  
Without  
Disease.®

# Monkeypox outbreak

## Confirmed Cases

**75,885**

Total Cases

**74,994**

in locations that have not historically reported monkeypox

**891**

in locations that have historically reported monkeypox

## Locations with cases

**109**

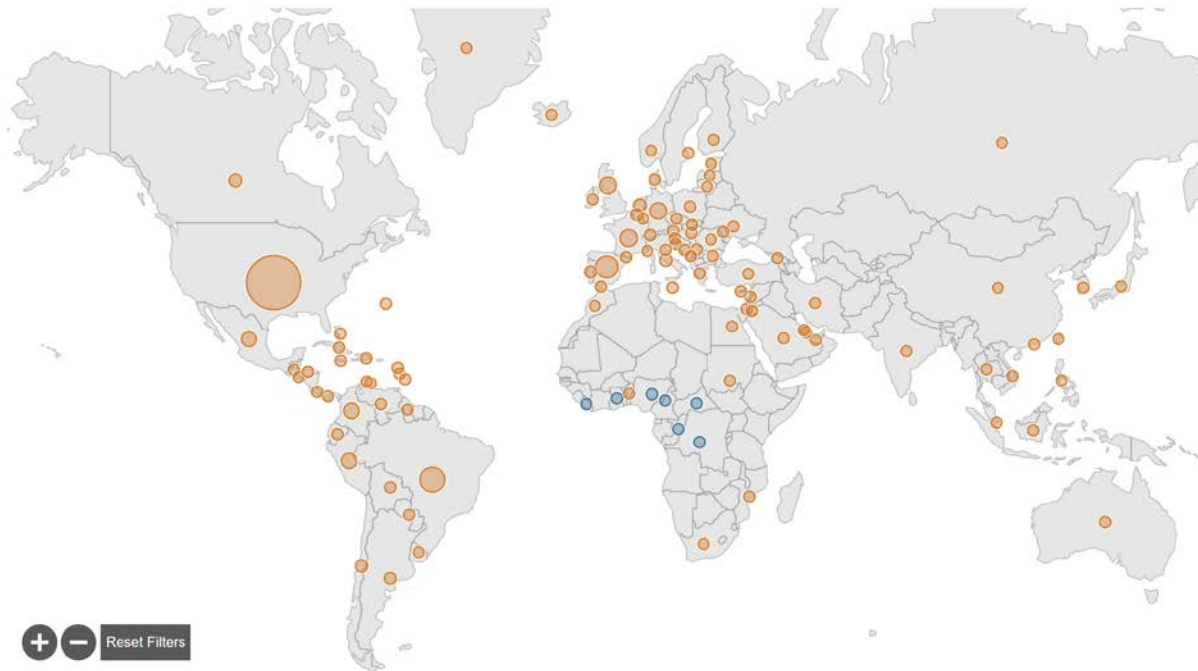
Total

**102**

Has not historically reported monkeypox

**7**

Has historically reported monkeypox

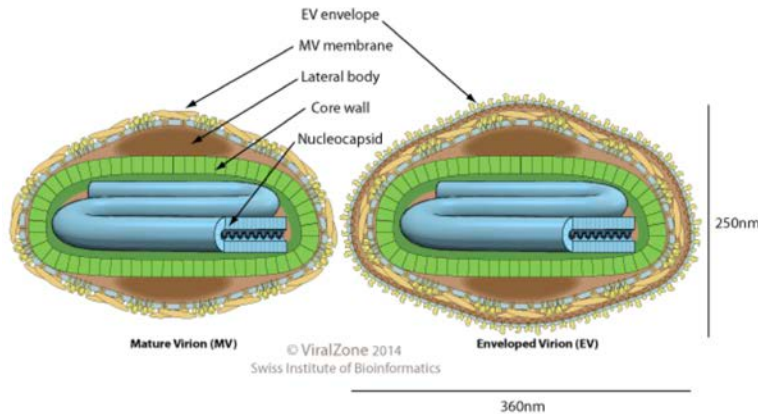


## Legend

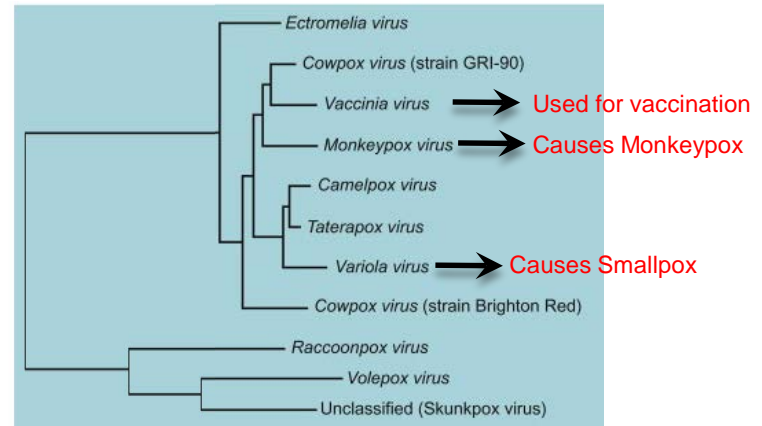
● Has not historically reported monkeypox

● Has historically reported monkeypox

# Orthopoxviruses



## Orthopoxvirus

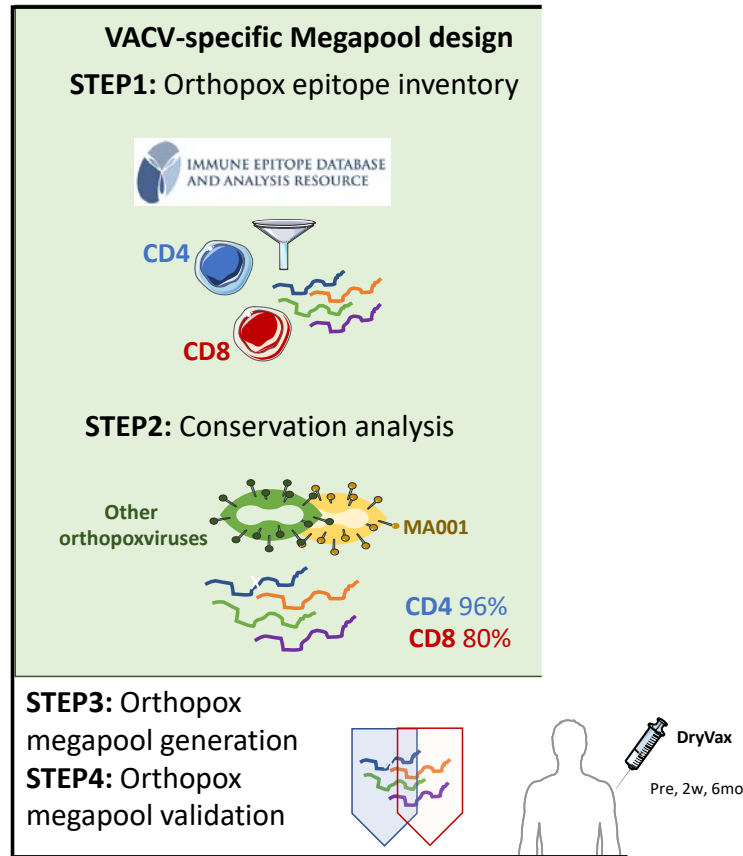


Virus Taxonomy, 2012 doi.org/10.1016/B978-0-12-384684-6.00028-8.

- All Orthopox viruses vaccines are based on **vaccinia virus**:
  - *Dryvax*: live vaccine with combination of vaccinia strains discontinued in 1972.  
**High efficacy, Low safety profile ORFs ≈ 240**
  - *Acam2000*: live vaccine, single vaccinia strains from *Dryvax*. Comparable to *Dryvax*.
  - *MVA (Jynneos)*: live vaccine non-replicating modified vaccinia Ankara  
**Efficacy tested only in animal models, High safety profile ORFs ≈ 157**

***Acam2000 and MVA are both currently licensed for Monkeypox (ORFs ≈ 200)***

# Design peptide pools able to detect vaccine responses



Grifoni, Zhang.....Scheuermann, Sette Cell Host & Microbe 2022

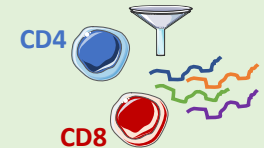
# VACV-specific Megapool design

**Table 1. IEDB inventory of orthopox virus CD4 and CD8 T cell epitopes**

Type	Host	Orthopox virus					Total
		Cowpox	Ectromelia	Monkeypox	Vaccinia	Variola	
CD4	Humans	0	0	0	209	38	247
	Macaques	0	0	0	0	0	0
	Tg mice	0	0	0	0	0	0
	Mice	0	40	0	31	0	71
	<b>Any</b>	<b>0</b>	<b>40</b>	<b>0</b>	<b>240</b>	<b>38</b>	<b>318</b>
CD8	Humans	0	0	0	207	31	238
	Macaques	0	0	2	17	0	19
	Tg mice	0	0	0	182	0	182
	Mice	1	2	0	217	0	220
	<b>Any</b>	<b>1</b>	<b>2</b>	<b>2</b>	<b>623</b>	<b>31</b>	<b>659</b>

Tallies are non-redundant diminishing: macaques does not include those also recognized in humans, Tg mice does not include those recognized in humans or macaques, etc.

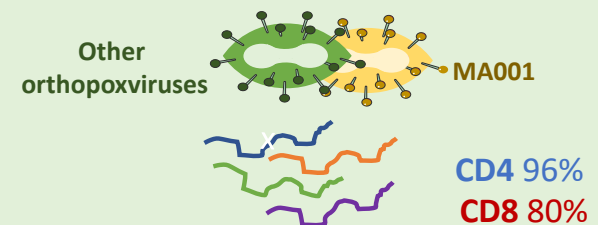
## STEP1: Orthopox epitope inventory



**OPXV CD4 MP:** 318 epitopes identified in any host

**OPXV CD8 MP:** 238 epitopes identified only in Human

## STEP2: Conservation analysis



Grifoni, Zhang.....Scheuermann, Sette *Cell Host & Microbe* 2022

# How to use IEDB to extract VACV epitopes



## CD4 epitope query

The screenshot shows the IEDB website interface with the following sections:

- Welcome:** Introduction to the IEDB as a freely available resource for antibody and T cell epitopes.
- START YOUR SEARCH HERE:** Search filters for Epitope, Assay, Epitope Source, MHC Restriction, Host, and Disease.
- Epitope Analysis Resource:** Tools for T Cell and B Cell Epitope Prediction.
- Summary Metrics:** A table showing the number of entries in various categories.

**Epitope Search Filters:**

- Epitope:**  Any,  Linear peptide,  Discontinuous,  Non-peptidic. Search term: **Exact** (Ex: SIINFEKL).
- Assay:**  T Cell,  B Cell,  MHC Ligand. Outcome:  Positive,  Negative. (Ex: neutralization).
- Epitope Source:** Organism: **Orthopoxvirus (ID:102)**. Antigen: (Ex: core, capsid, myo).
- MHC Restriction:**  Any,  Class I,  Class II,  Non-classical. (Ex: HLA-A\*02:01).
- Host:**  Any,  Human,  Mouse,  Non-human primate. (Ex: dog, camel).
- Disease:**  Any,  Infectious,  Allergic,  Autoimmune. (Ex: asthma).

**Epitope Analysis Resource:**

- T Cell Epitope Prediction:** Scan an antigen sequence for amino acid patterns indicative of: MHC I Binding, MHC II Binding, MHC I Processing (Proteasome, TAP), MHC I Immunogenicity.
- B Cell Epitope Prediction:** Predict linear B cell epitopes using: Antigen Sequence Properties. Predict discontinuous B cell epitopes using antigen structure via: Discotope, ElliPro.
- Epitope Analysis Tools:** Analyze epitope sets of: Population Coverage, Conservation Across Antigens, Clusters with Similar Sequences.

**Summary Metrics:**

Category	Count
Peptidic Epitopes	1,545,392
Non-Peptidic Epitopes	3,147
T Cell Assays	446,386
B Cell Assays	1,335,277
MHC Ligand Assays	4,683,598
Epitope Source Organisms	4,241
Restricting MHC Alleles	971
References	23,343



# How to use IEDB to extract VACV epitopes



## CD4 epitope results : Epitopes

IEDB.org: View Results and Refine Search

iedb.org/result\_v3.php?cookie\_id=d9f90a

IMMUNE EPITOPE DATABASE AND ANALYSIS RESOURCE

Home Specialized Searches Analysis Resource

Help More IEDB

Pending Filters

Reset Search

Filter Options

T Cell

Epitope

Any

Linear peptide

Length

Sequence

Discontinuous

Non-peptidic

3D structure assays

Amino acid modification

Epitope Source

Organism

Orthopoxvirus (ID:10242)

Antigen

Current Filters: **X** Organism: Orthopoxvirus (ID:10242) **X** Include Positive Assays **X** No B cell assays **X** No MHC assays **X** MHC Restriction Type: Class II

Epitopes (345) Antigens (133) Assays (720) Receptors (0) References (38)

Go To Records Starting At 1200

Export Results

345 Records Found

Page 1 of 14

25 Per Page

IEDB ID	Epitope	Antigen	Organism	# References	# Assays
51567	QLVFNSISARALKAY	Telomere-binding protein I1	Vaccinia virus (vaccinia virus VV)	7	12
28568	ISKYAGINILNVYSP	Core protein VP8	Vaccinia virus (vaccinia virus VV)	5	11
47780	PGVMYAFTTPLISFF	Envelope protein H3	Vaccinia virus (vaccinia virus VV)	5	10
49543	PSVFINPISHTSYCY	DNA polymerase	Vaccinia virus (vaccinia virus VV)	5	13
7760	DDDYGEPIITSYLQ	DNA-directed RNA polymerase 22 kDa subunit	Vaccinia virus (vaccinia virus VV)	4	5
36810	LKAYFTAKINEMVDE	Telomere-binding protein I1	Vaccinia virus (vaccinia virus VV)	4	6
48068	PKGFYASPSVKTSLV	Transcript termination protein A18	Vaccinia virus (vaccinia virus VV)	4	5
48083	PKIFFRPTTITANVS	Scaffold protein D13	Vaccinia virus (vaccinia virus VV)	4	9
65753	TPRYIPSTSISSSNI	Protein F15	Vaccinia virus (vaccinia virus VV)	4	5
69806	VLTIKAPNVISSKIS	Poly(A) polymerase catalytic subunit	Vaccinia virus (vaccinia virus VV)	4	5
9473	DNIFIPSVITKSGKK	DNA polymerase processivity factor component A20	Vaccinia virus (vaccinia virus VV)	3	3
17914	FTCDQGYHSSDPNAV	Protein B5	Vaccinia virus (vaccinia virus VV)	3	7
19296	GEIIRAATTSPAREN	Cell surface-binding protein	Vaccinia virus (vaccinia virus VV)	3	4
26418	ILVITDQVLAQFEE	DNA-directed RNA polymerase 22 kDa subunit	Vaccinia virus (vaccinia virus VV)	3	3

# How to use IEDB to extract VACV epitopes



## CD4 epitope results : Assays

IEDB.org: View Results and Refine Search

iedb.org/result\_v3.php?cookie\_id=d9f90a

Home Specialized Searches Analysis Resource

Current Filters:  Organism: Orthopoxvirus (ID:10242)  Include Positive Assays  No B cell assays  No MHC assays  MHC Restriction Type: Class II

Epitopes (345) Antigens (133) Assays (720) Receptors (0) References (38)

T Cell Assays (720) B Cell Assays (0) MHC Ligand Assays (0)

Go To Records Starting At   Export Results

720 Records Found Page 1 of 29 25 Per Page

IEDB ID	Reference	Epitope	Host	Immunization	Assay Antigen	Antigen Epitope Relation	MHC Restriction	Assay Description
1835642	Lichen Jing; J Immunol Methods 2009	YVLSLHIYWGK E IMV membrane protein (61-73) Vaccinia virus (vaccinia virus VV)	Homo sapiens (human)	Prophylactic vaccination with Vaccinia virus NYCBH - Dryvax (Taxonomic Child) followed by restimulation in vitro	YVLSLHIYWGK E IMV membrane protein (61-73) Vaccinia virus (vaccinia virus VV)	Epitope	HLA-DQA1*01:02/DQB1*06:02	3H-thymidine proliferation Positive
1835641	Lichen Jing; J Immunol Methods 2009	SAMVYSSDDIPP R double-strand RNA-binding protein (53-65) Vaccinia virus (vaccinia virus VV)	Homo sapiens (human)	Prophylactic vaccination with Vaccinia virus NYCBH - Dryvax (Taxonomic Child) followed by restimulation in vitro	SAMVYSSDDIPP R double-strand RNA-binding protein (53-65) Vaccinia virus (vaccinia virus VV)	Epitope	HLA-DQA1*01:02/DQB1*06:02	3H-thymidine proliferation Positive
2370972	David M. Koelle M.D.; IEDB Submission 2014	RKLTLENAELSD K A-type inclusion protein A25 (432-444)	Homo sapiens (human)	Administration in vivo with Vaccinia virus (vaccinia virus VV) (Source Organism)	RKLTLENAELSD K A-type inclusion protein A25 (432-444)	Epitope	HLA-DRB1*15:01	3H-thymidine proliferation Positive

Filter Options: T Cell

Epitope: Any, Linear peptide, Length, Sequence, Discontinuous, Non-peptidic, 3D structure assays, Amino acid modification

Epitope Source: Organism: Orthopoxvirus (ID:10242) 1, Antigen



# How to use IEDB to extract VACV epitopes



## CD4 epitope results : References

IEDB.org: View Results and Refine Search

iedb.org/result\_v3.php?cookie\_id=d9f90a

IMMUNE EPITOPE DATABASE AND ANALYSIS RESOURCE

Home Specialized Searches Analysis Resource

Pending Filters

Reset Search

Filter Options

T Cell

Epitope

Any

Linear peptide

Length

Sequence

Discontinuous

Non-peptidic

3D structure assays

Amino acid modification

Epitope Source

Organism

Orthopoxvirus (ID:10242) 1

Antigen

Current Filters:  Organism: Orthopoxvirus (ID:10242)  Include Positive Assays  No B cell assays  No MHC assays  MHC Restriction Type: Class II

Epitopes (345) Antigens (133) Assays (720) Receptors (0) References (38)

Go To Records Starting At 1982 GO Export Results

38 Records Found Page 1 of 2 25 Per Page

IEDB ID	PMID	Author	Title	Journal	Date
1037262	32747299	Jun Ando; Minhtran C Ngo; Miki Ando; Ann Leen; Cliona M Rooney	Identification of protective T-cell antigens for smallpox vaccines.	Cytherapy	2020
1035464	Submission	David M. Koelle M.D.; Lichen Jing Ph.D.; Kerry J. Laing Ph.D.; Lichun Dong M.S.; Victoria L. Campbell B.S.; Alessandro Sette DR. BIOL.SCI	Identification of CD4+ T cell epitopes in humans vaccinated with vaccinia		2019
1034653	30700590	Katherine S Forsyth; Brian DeHaven; Mark Mendonca; Sinu Paul; Alessandro Sette; Laurence C Eisenlohr	Poor Antigen Processing of Poxvirus Particles Limits CD4+ T Cell Recognition and Impacts Immunogenicity of the Inactivated Vaccine.	J Immunol	2019
1033295	Submission	David M. Koelle M.D.; Lichen Jing Ph.D.; Kerry J. Laing Ph.D.; Lichun Dong M.S.; Victoria L. Campbell B.S.; Alessandro Sette DR. BIOL.SCI	Identification of CD4+ T cell epitopes in humans vaccinated with vaccinia		2018
1032285	Submission	David M. Koelle M.D.; Lichen Jing Ph.D.; Kerry J. Laing Ph.D.; Lichun Dong M.S.; Victoria L. Campbell B.S.	Identification of CD4+ T cell epitopes in humans vaccinated with Dryvax vaccine		2017
1029750	Submission	David M. Koelle M.D.; Lichen Jing Ph.D.; Kerry J. Laing Ph.D.; Lichun Dong M.S.; Victoria L. Campbell B.S.	Identification of CD4+ T cell epitopes in humans vaccinated with Dryvax® vaccine		2016
1028784	Submission	David M. Koelle M.D.; Lichen Jing Ph.D.;	Identification of CD4+ T cell epitopes in		2015

# How to use IEDB to extract VACV epitopes



## CD8 epitope query

The screenshot shows the IEDB website interface with a search query for a CD8 epitope. The search criteria are as follows:

- Epitope:** Any, Linear peptide, **Exact** (SIINFEKL), Discontinuous, Non-peptidic
- Assay:** T Cell, B Cell, MHC Ligand; Outcome: Positive
- Epitope Source:** Organism: Orthopoxvirus (ID:102); Antigen: core, capsid, myosin
- MHC Restriction:** Class I, Class II, Non-classical; Ex: HLA-A\*02:01
- Host:** Human, Mouse, Non-human primate; Ex: dog, camel
- Disease:** Any, Infectious, Allergic, Autoimmune; Ex: asthma

The interface includes a 'Reset' button and a 'Search' button. On the right, there are links to 'T Cell Epitope Prediction', 'B Cell Epitope Prediction', and 'Epitope Analysis Tools'.

**Welcome**

The Immune Epitope Database (IEDB) is a freely available resource funded by NIAID. It catalogs experimental data on antibody and T cell epitopes studied in humans, non-human primates, and other animal species in the context of infectious disease, allergy, autoimmunity and transplantation. The IEDB also hosts tools to assist in the prediction and analysis of epitopes.

[Learn More](#)

**Upcoming Events & News**

AAI Exhibitor Booth	May 6-10
FOCUS Exhibitor Booth	June 21-24
<a href="#">Virtual User Workshop</a>	Oct 26-28

\* register [here](#)

[IEDB SARS-CoV-2 Epitope Analysis Videos](#)

**Summary Metrics**

Peptidic Epitopes	1,545,392
Non-Peptidic Epitopes	3,147
T Cell Assays	446,386
B Cell Assays	1,335,277
MHC Ligand Assays	4,683,598
Epitope Source Organisms	4,241
Restricting MHC Alleles	971
References	23,343

**START YOUR SEARCH HERE**

**Epitope**

Any  
 Linear peptide  
**Exact** Ex: SIINFEKL  
 Discontinuous  
 Non-peptidic

**Assay**

T Cell  
 B Cell  
 MHC Ligand  
Ex: neutralization **Find**  
Outcome:  Positive  Negative

**Epitope Source**

Organism  
Orthopoxvirus (ID:102) **Find**  
Antigen  
Ex: core, capsid, myosin **Find**

**MHC Restriction**

Any  
 Class I  
 Class II  
 Non-classical  
Ex: HLA-A\*02:01 **Find**

**Host**

Any  
 Human  
 Mouse  
 Non-human primate  
Ex: dog, camel **Find**

**Disease**

Any  
 Infectious  
 Allergic  
 Autoimmune  
Ex: asthma **Find**

**Epitope Analysis Resource**

**T Cell Epitope Prediction**

Scan an antigen sequence for amino acid patterns indicative of:

- MHC I Binding
- MHC II Binding
- MHC I Processing (Proteasome,TAP)
- MHC I Immunogenicity

**B Cell Epitope Prediction**

Predict linear B cell epitopes using:

- Antigen Sequence Properties

Predict discontinuous B cell epitopes using antigen structure via:

- DiscoTope
- EIIPro

**Epitope Analysis Tools**

Analyze epitope sets of:

- Population Coverage
- Conservation Across Antigens
- Clusters with Similar Sequences

**Reset** **Search**

# How to use IEDB to extract VACV epitopes



## CD8 epitope results : Epitopes

IEDB.org: View Results and Refine Search

iedb.org/result\_v3.php?cookie\_id=25beae

IMMUNE EPITOPE DATABASE AND ANALYSIS RESOURCE

Home Specialized Searches Analysis Resource

Pending Filters:

Filter Options ?

T Cell

Epitope ?

Any

Linear peptide

Length

Sequence

Discontinuous

Non-peptidic

3D structure assays

Amino acid modification

Epitope Source ?

Organism

Orthopoxvirus (ID:10242) 1

Antigen

Current Filters:  Organism: Orthopoxvirus (ID:10242)  Include Positive Assays  No B cell assays  No MHC assays  MHC Restriction Type: Class I

Host: Homo sapiens (human)

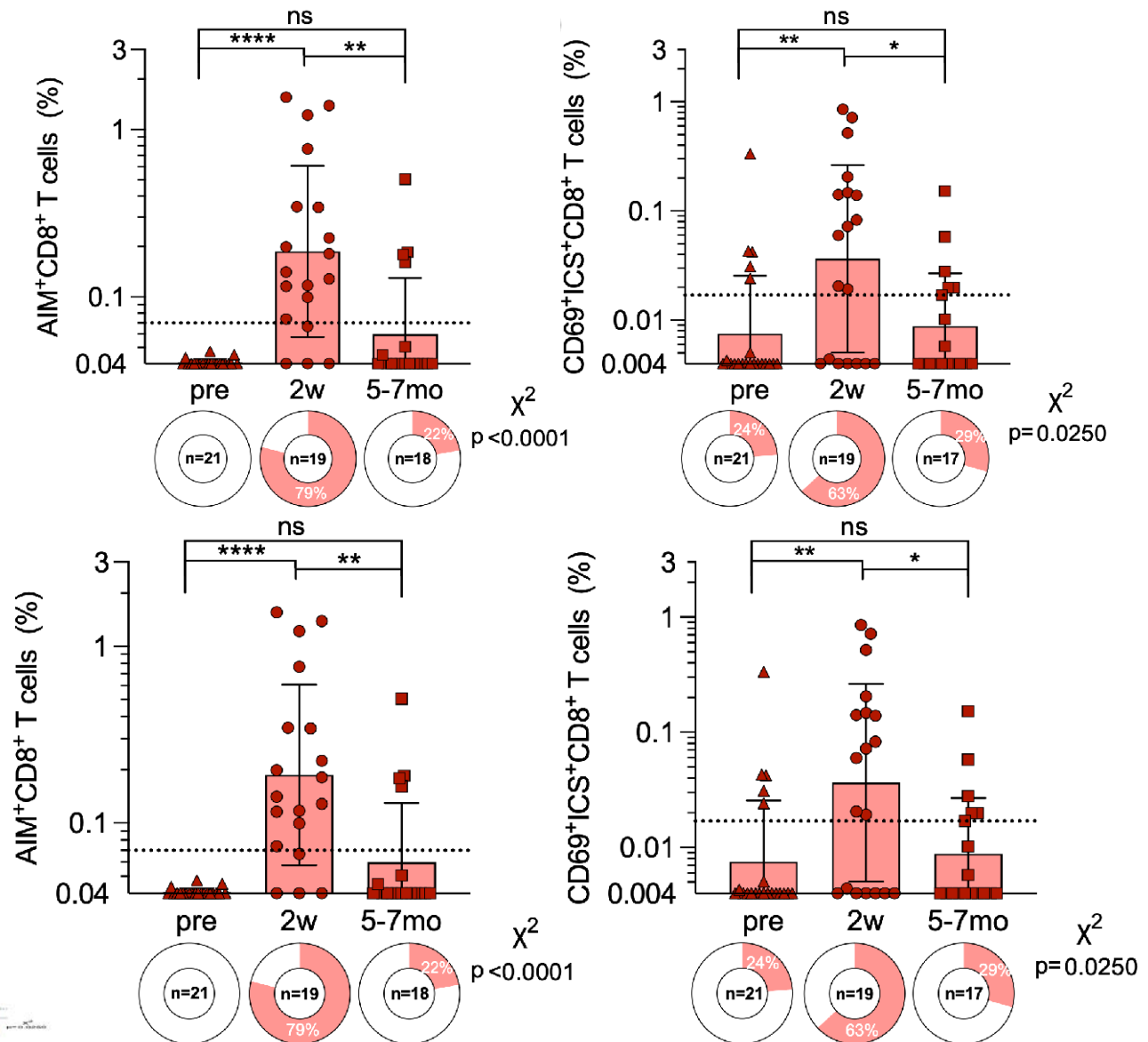
Epitopes (249) Antigens (136) Assays (487) Receptors (0) References (27)

Go To Records Starting At 1200  Export Results

249 Records Found Page 1 of 10 Per Page 25

IEDB ID	Epitope	Antigen	Organism	# References	# Assays
33967	KVDDTFYV	Interferon antagonist C7	Vaccinia virus (vaccinia virus VV)	10	15
26990	ILDDNLYKV	Putative nuclease G5	Vaccinia virus (vaccinia virus VV)	7	9
6630	CLTEYILWV	Protein C16/B22	Vaccinia virus (vaccinia virus VV)	6	9
31209	KIDYYIPV	Protein E2	Vaccinia virus (vaccinia virus VV)	6	7
16929	FLTSVINRV	Protein F12	Vaccinia virus (vaccinia virus VV)	5	8
21044	GLNDYLHSV	Protein O1	Vaccinia virus (vaccinia virus VV)	5	8
42262	MPAYIRNTL	DNA-directed RNA polymerase 147 kDa polypeptide	Vaccinia virus (vaccinia virus VV)	5	7
44702	NLFDIPLTV	Protein F12	Vaccinia virus (vaccinia virus VV)	5	7
16781	FLNISWFYI	DNA polymerase	Vaccinia virus (vaccinia virus VV)	4	4
55235	RPMSLRSTII	Protein O1	Vaccinia virus (vaccinia virus VV)	4	4
71936	VWINNSWKF	Primase D5	Vaccinia virus (vaccinia virus VV)	4	5
74418	YIYGIPLSL	Kelch repeat and BTB domain-containing protein 1	Vaccinia virus (vaccinia virus VV)	4	4
5398	AVKDVITKK	Intermediate transcription factor 3 small	Vaccinia virus (vaccinia virus VV)	3	3

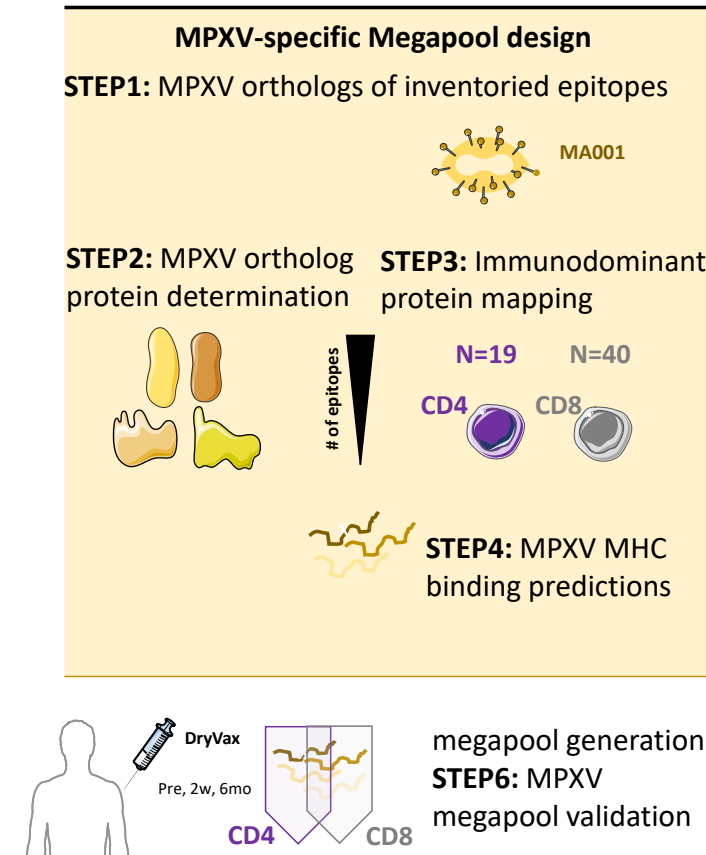
# Testing VACV pools on a Dryvax vaccinated cohort



Grifoni, Zhang.....  
Scheuermann, Sette Cell  
Host & Microbe 2022



# Design peptide pools able to detect MPXV responses

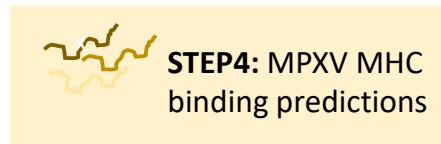
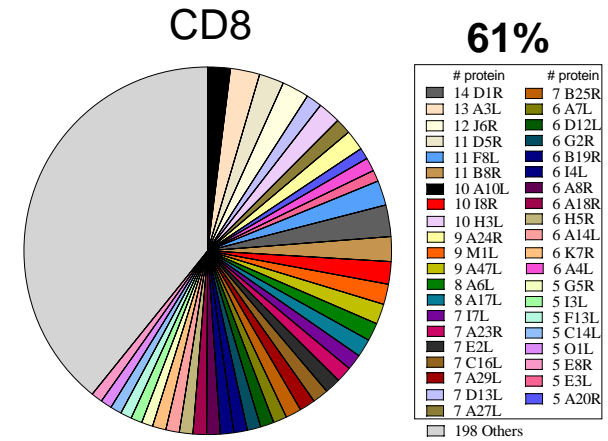
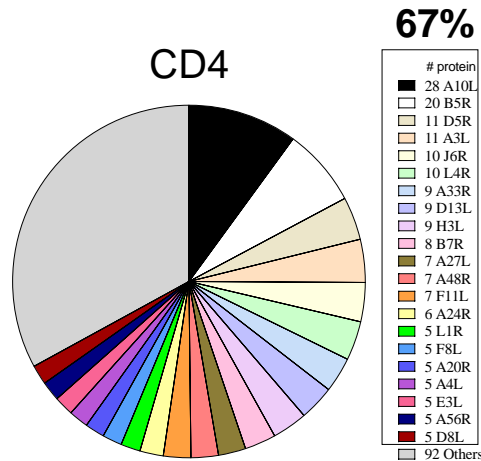
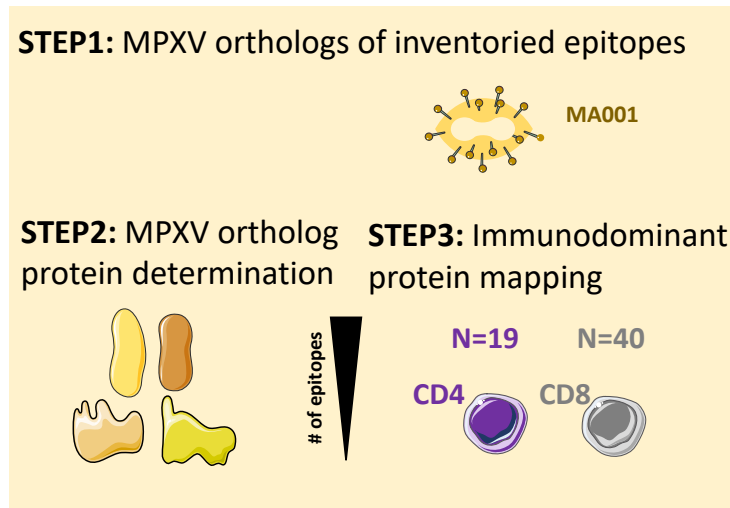


Grifoni, Zhang.....Scheuermann, Sette *Cell Host & Microbe* 2022



# MPXV-specific Megapool design

Selected proteins with 5 or more epitopes



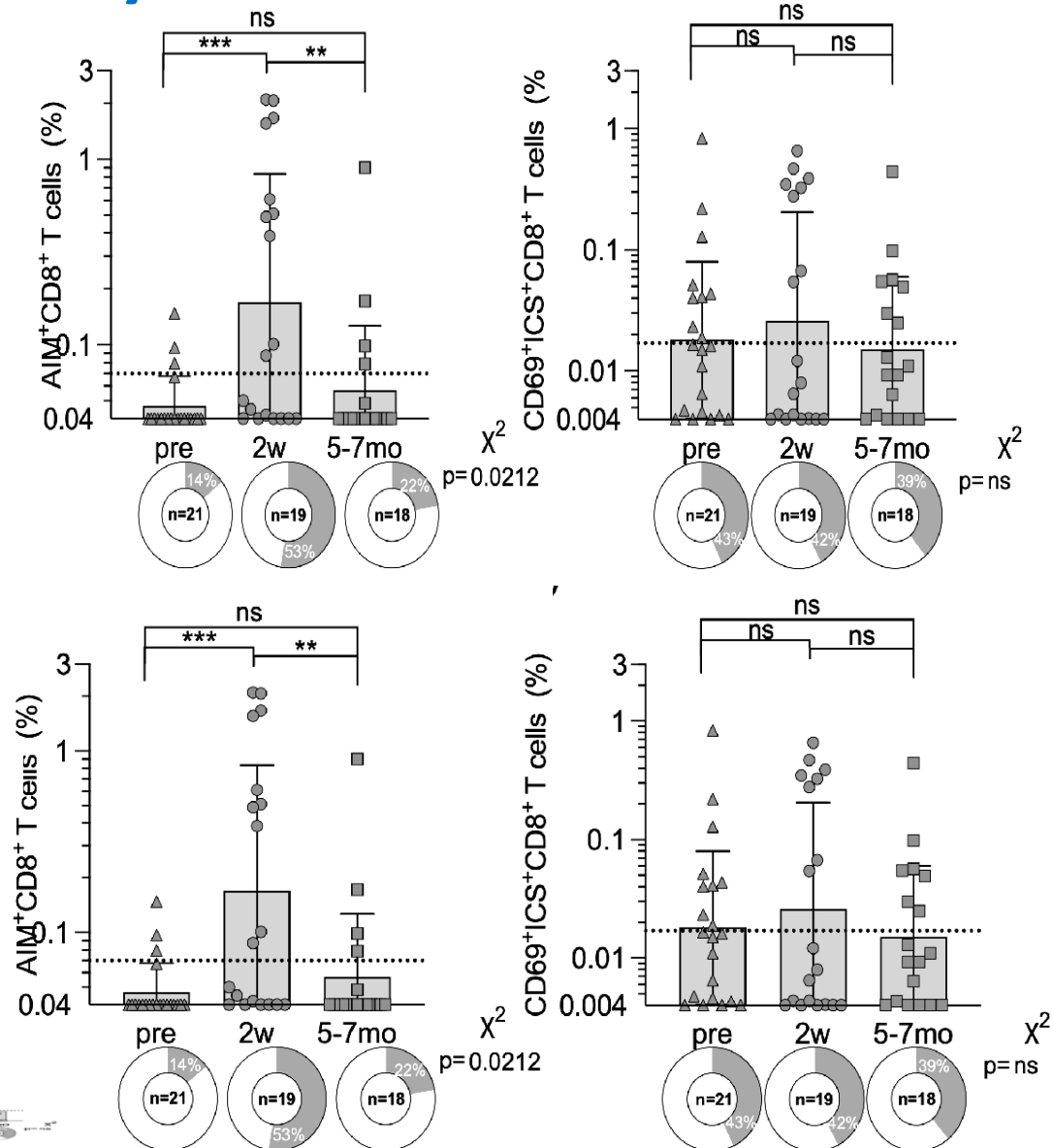
MPXV CD4 MP: 276

MPXV CD8 MP P1-P5: 1647- divided in 5 pools

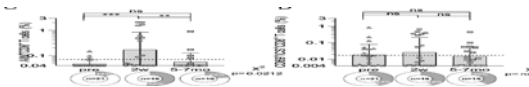
Grifoni, Zhang.....Scheuermann, Sette Cell Host & Microbe 2022



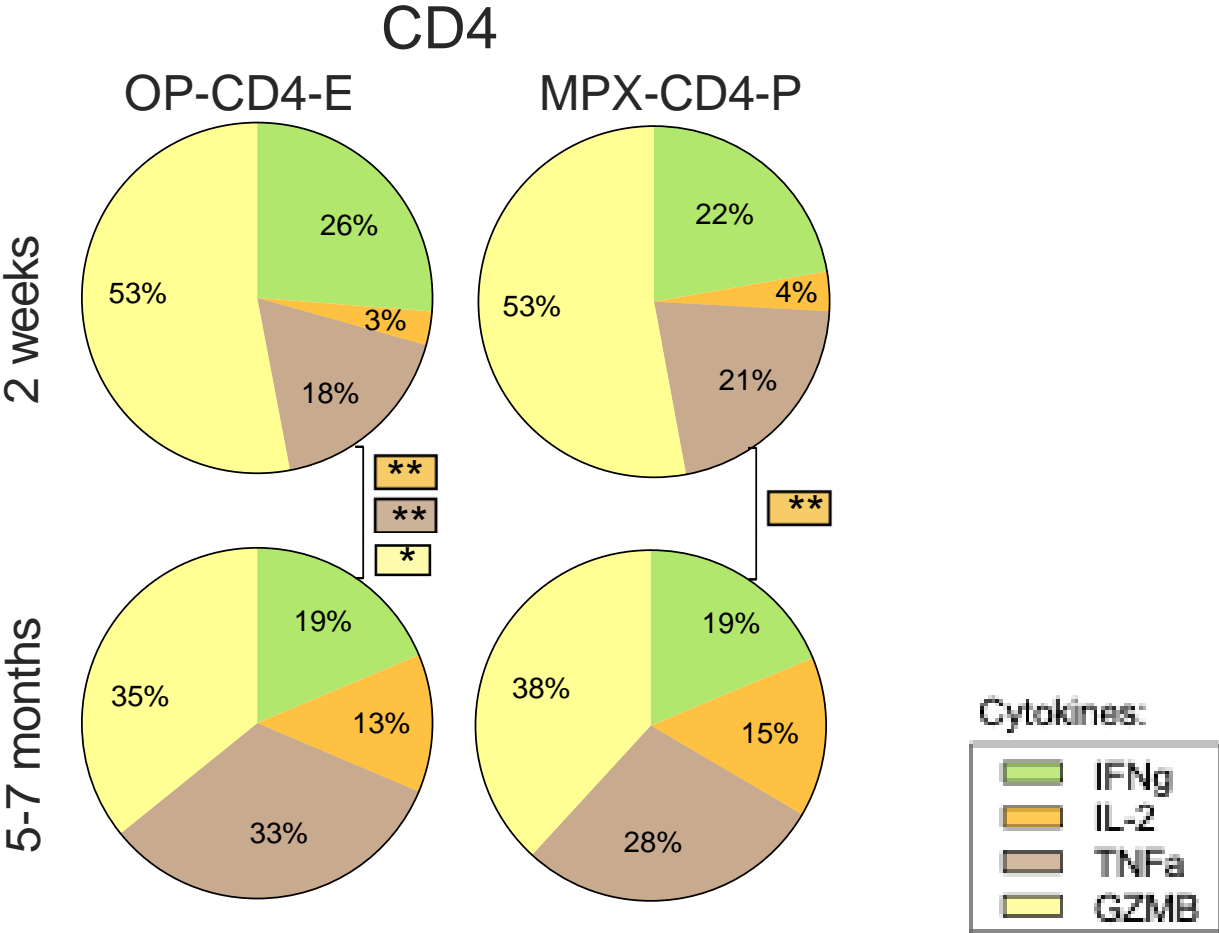
# Testing MPXV pools to assess T cell cross-reactivity on a Dryvax vaccinated cohort



Grifoni, Zhang.....  
 Scheuermann, Sette Cell Host  
 & Microbe 2022

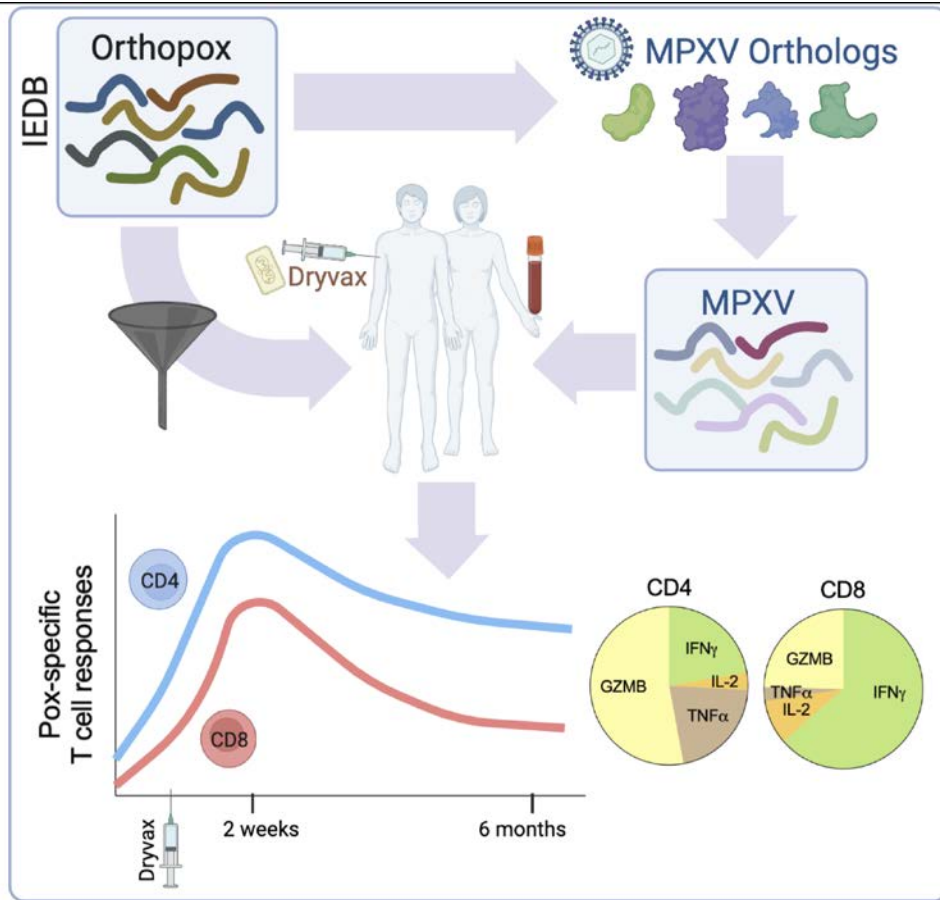


# Pox-specific T cells produce multiple cytokines



Grifoni, Zhang.....Scheuermann, Sette Cell Host & Microbe 2022

# Conclusions



- We defined dominant cross-reactive ORFs to generate peptide MPs to measure T cell responses
- Wide breadth of both CD4+ and CD8+ T cell immune responses
- T cell epitopes are largely conserved between VACV and MPXV
- CD4 responses are more durable over time than CD8
- There is a large population of Pox-specific Granzyme B+ CD40L+ CD4 T cells



# “How to use IEDB in your research”

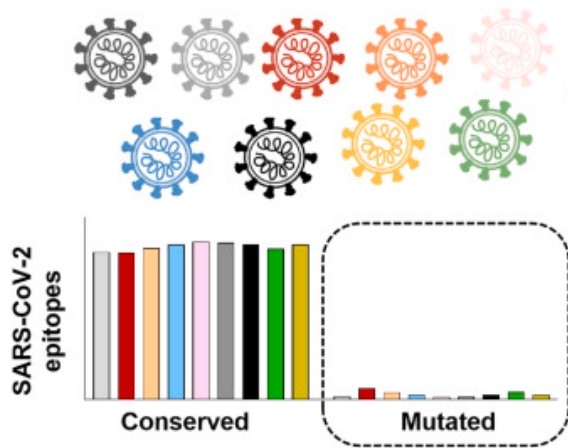
## Examples on SARS-CoV-2

Presented by: Alba Grifoni, PhD, Instructor/Research Faculty

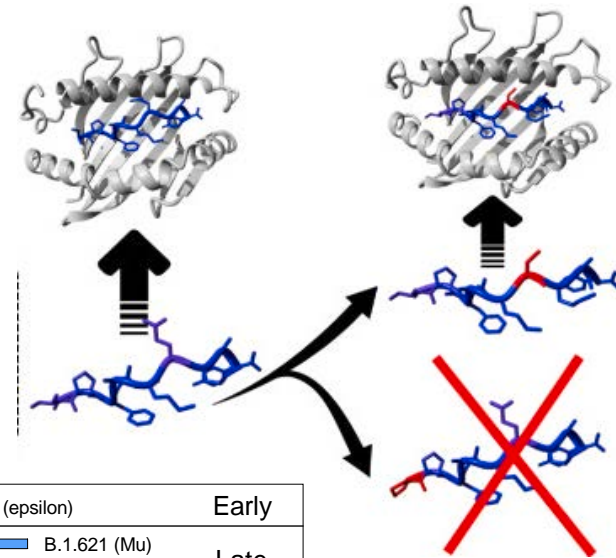
La Jolla  
Institute  
FOR IMMUNOLOGY

Life  
Without  
Disease.®

# Predicted impact of mutated epitopes

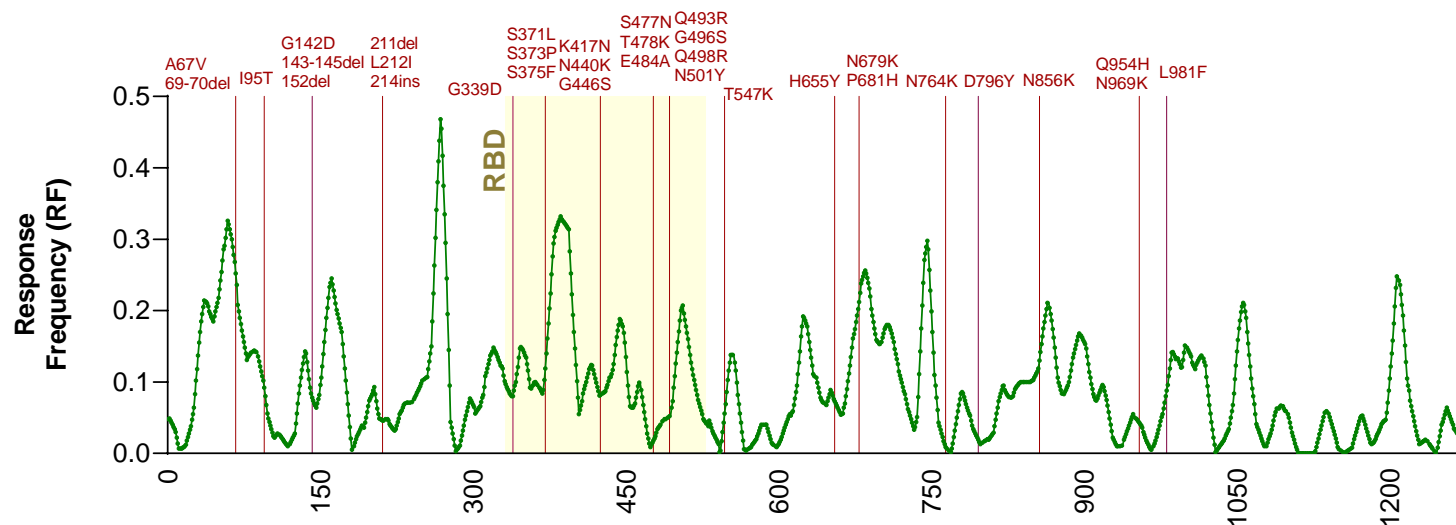
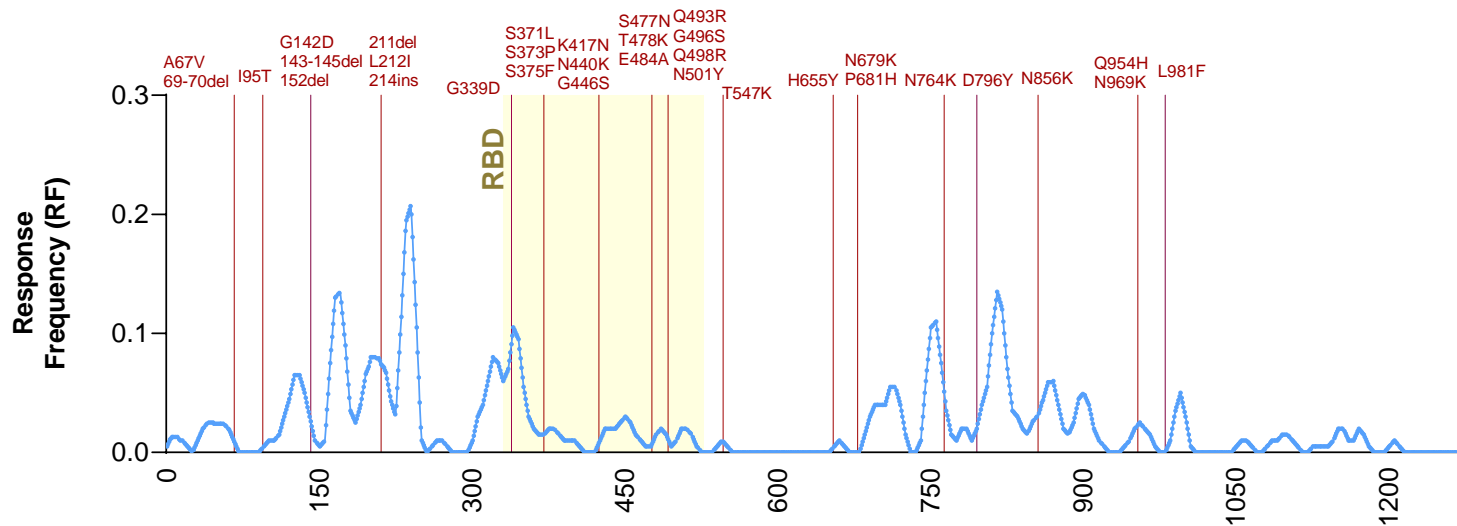


■ B.1.1.7 (alpha)	■ B.1.351 (beta)	■ P.1. (gamma)	■ B.1.427/429 (epsilon)	Early
■ B.1.1.519	■ B.1.525 (eta)	■ B.1.526 (iota)	■ B.1.526.1	Late
■ B.1.617.1 (kappa)	■ B.1.617.2 (delta)	■ C37 (lambda)	■ R1	
■ B.1.1529 (Omicron)				Ongoing



Tarke..... Grifoni and Sette Cell 2022  
 Grifoni and Sette CRI 2022

# Impact of spike Omicron mutations on T cell epitopes



Tarke Grifoni and Sette *Front. Bioinf.* 2022



# How to use ImmuneEpitopeBrowser to define spike T cell immunodominant regions



## CD4 epitope query

IEDB.org: Free epitope database and pr...  
iedb.org/home\_v3.php

### Welcome

The Immune Epitope Database (IEDB) is a freely available resource funded by NIAID. It catalogs experimental data on antibody and T cell epitopes studied in humans, non-human primates, and other animal species in the context of infectious disease, allergy, autoimmunity and transplantation. The IEDB also hosts tools to assist in the prediction and analysis of epitopes.

[Learn More](#)

### Upcoming Events & News

AAI Exhibitor Booth May 6-10  
FOCUS Exhibitor Booth June 21-24  
[Virtual User Workshop](#) Oct 26-28  
\* register [here](#)

[IEDB SARS-CoV-2 Epitope Analysis Videos](#)

### Summary Metrics

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### START YOUR SEARCH HERE

#### Epitope

Any  
 Linear peptide  
 Discontinuous  
 Non-peptidic

Exact

#### Assay

T Cell  
 B Cell  
 MHC Ligand

Ex: neutralization

Outcome:  Positive  Negative

#### Epitope Source

Organism

SARS-CoV2 (ID:2697)

Antigen

Ex: core, capsid, myosin

#### MHC Restriction

Any  
 Class I  
 Class II  
 Non-classical

Ex: HLA-A\*02:01

#### Host

Any  
 Human  
 Mouse  
 Non-human primate

Ex: dog, camel

#### Disease

Any  
 Infectious  
 Allergic  
 Autoimmune

Ex: asthma

### Epitope Analysis Resource

#### T Cell Epitope Prediction

Scan an antigen sequence for amino acid patterns indicative of:

- MHC I Binding
- MHC II Binding
- MHC I Processing (Proteasome,TAP)
- MHC I Immunogenicity

#### B Cell Epitope Prediction

Predict linear B cell epitopes using:

- Antigen Sequence Properties

Predict discontinuous B cell epitopes using antigen structure via:

- Discotope
- ElliPro

#### Epitope Analysis Tools

Analyze epitope sets of:

- Population Coverage
- Conservation Across Antigens
- Clusters with Similar Sequences

# How to use ImmuneBrowser to define spike T cell immunodominant regions



## CD4 epitope results : Antigen

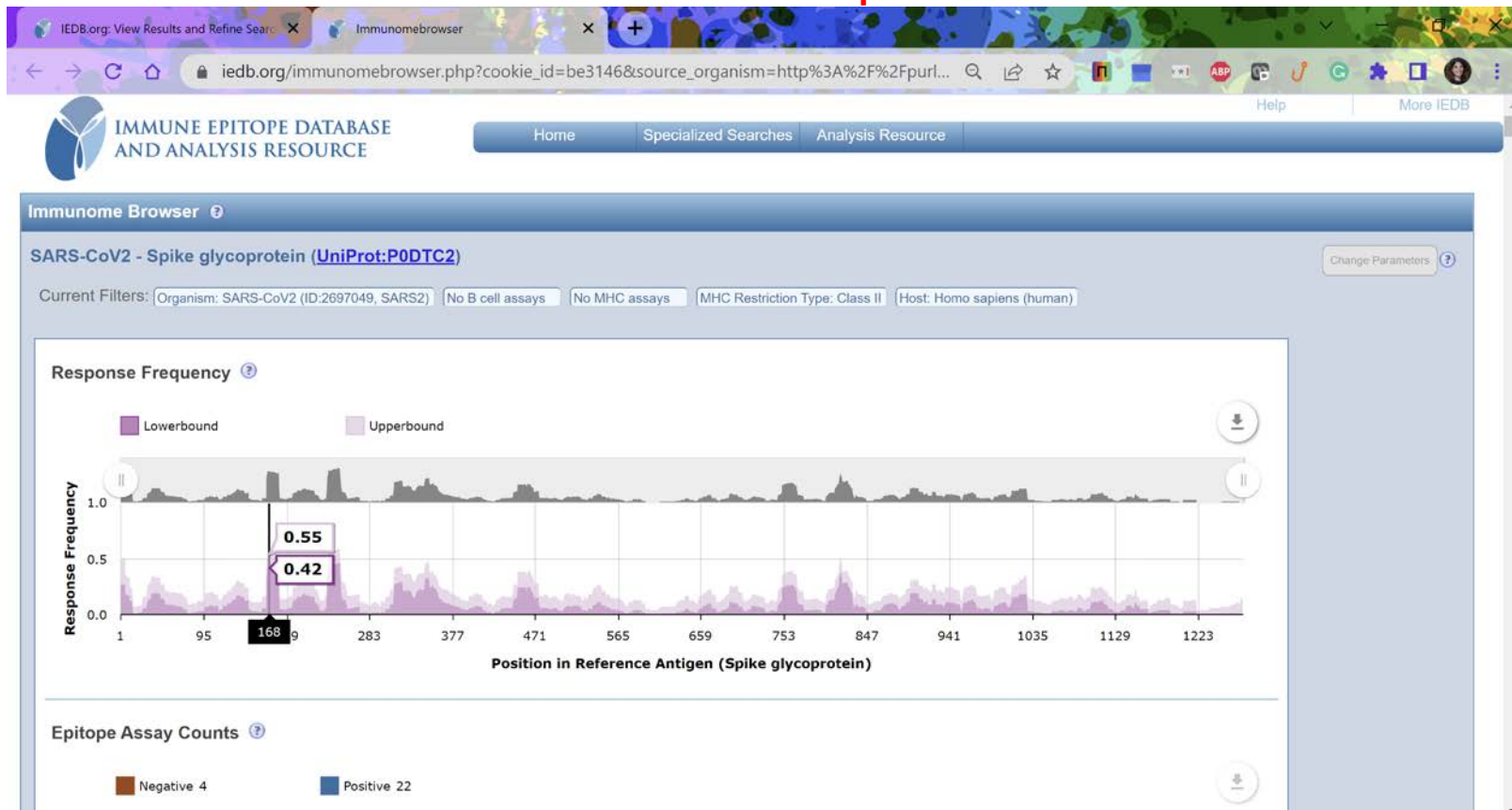
The screenshot displays the IEDB search results page for CD4 epitopes. The search criteria include: Organism: SARS-CoV2 (ID:2697049, SARS2), Include Positive Assays, No B cell assays, No MHC assays, MHC Restriction Type: Class II, and Host: Homo sapiens (human). The results table shows 12 records found, with columns for Antigen, Organism, # Epitopes, # Assays, and # References. A pop-up window titled 'Click icon to view Immune Browser' is overlaid on the table, showing a 'Response Frequency' graph for 'Influenza A Hemagglutinin' (Host: Homo sapiens, Assay: B cell assays). The graph plots Response Frequency (0.0 to 1.0) against position (1 to 183). The graph shows a high response frequency (near 1.0) for positions 1-100 and a lower response frequency (around 0.5) for positions 100-183. The graph also shows a 'Lowerbound' and 'Upperbound' for the response frequency.

Antigen	Organism	# Epitopes	# Assays	# References
Spike glycoprotein	Influenza A Hemagglutinin	42	27	23
Nucleoprotein		12	11	8
Membrane protein		8	8	5
Replicase polyprotein 1ab		5	5	5
Envelope small membrane protein		3	2	1
ORF8 protein		3	2	1
ORF7a protein		2	1	1
ORF6 protein		2	1	1
ORF3a protein		1	1	1
ORF10 protein		1	1	1
Replicase polyprotein 1a		1	1	1
ORF7b protein		1	1	1

# How to use ImmunomeBrowser to define spike T cell immunodominant regions



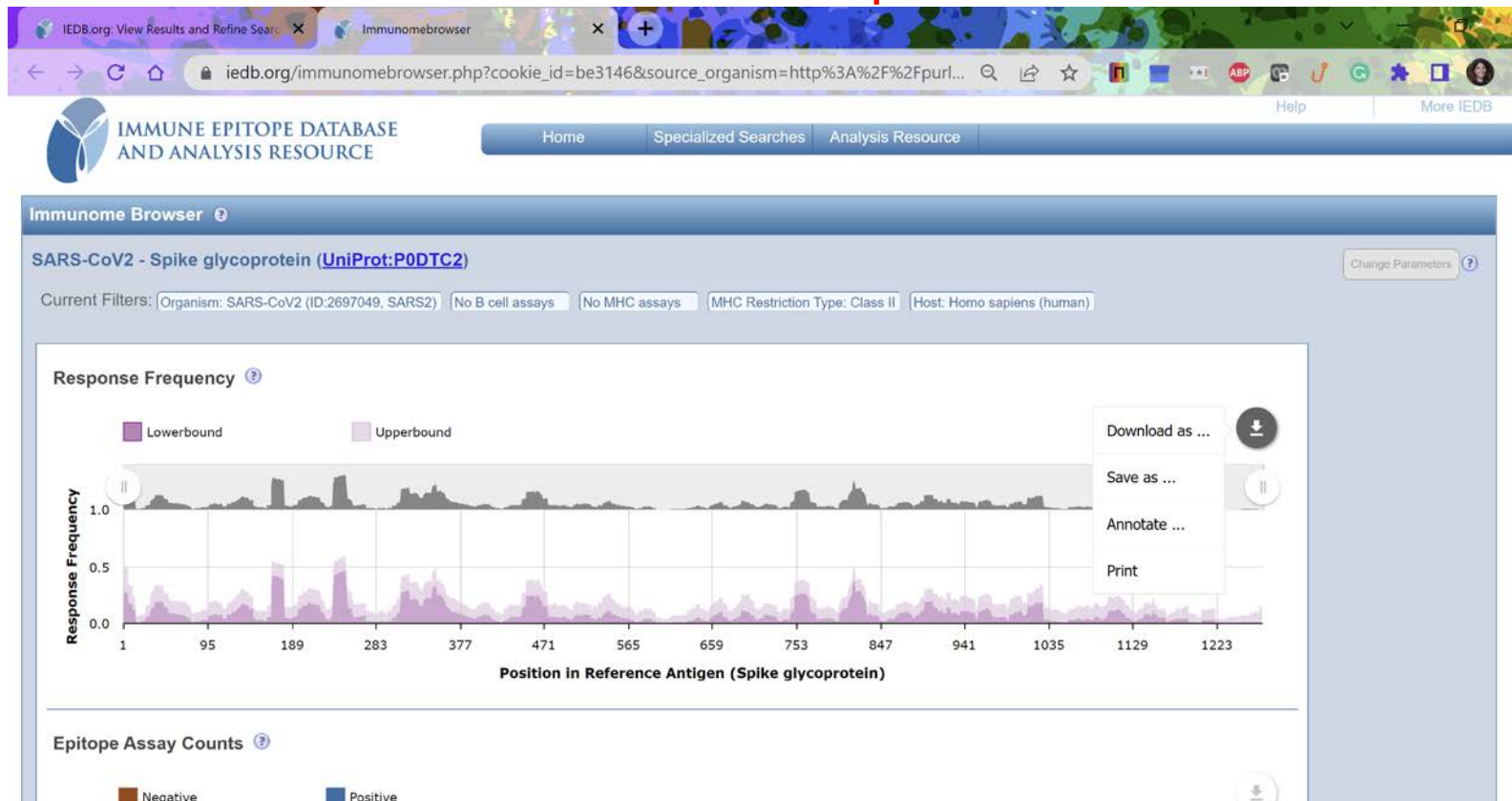
## CD4 Immunobrowser: Spike



# How to use ImmunomeBrowser to define spike T cell immunodominant regions



## CD4 Immunobrowser: Spike

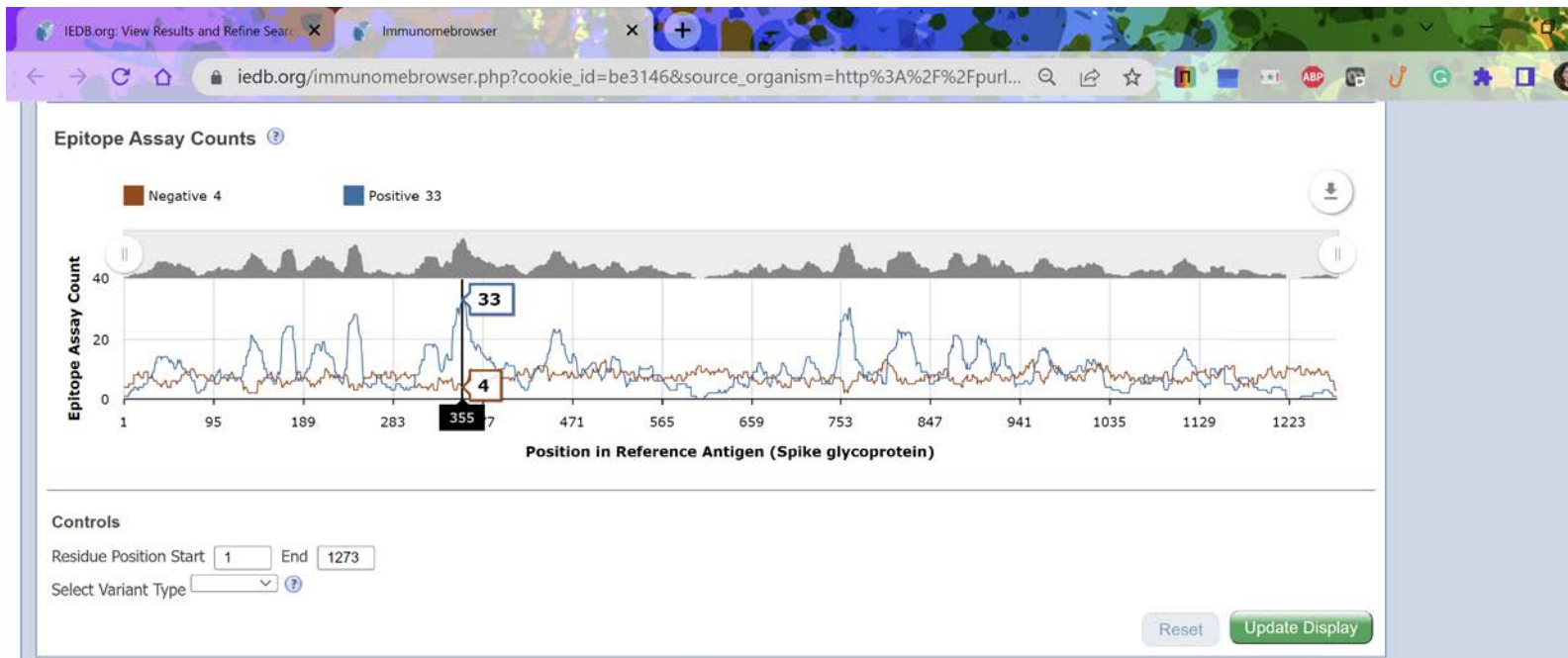




# How to use ImmunomeBrowser to define spike T cell immunodominant regions



## CD4 Immunobrowser: Spike



# How to use ImmunomeBrowser to define spike T cell immunodominant regions



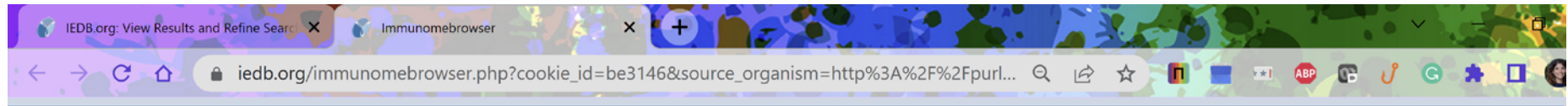
**CD4 Immunobrowser: Spike**



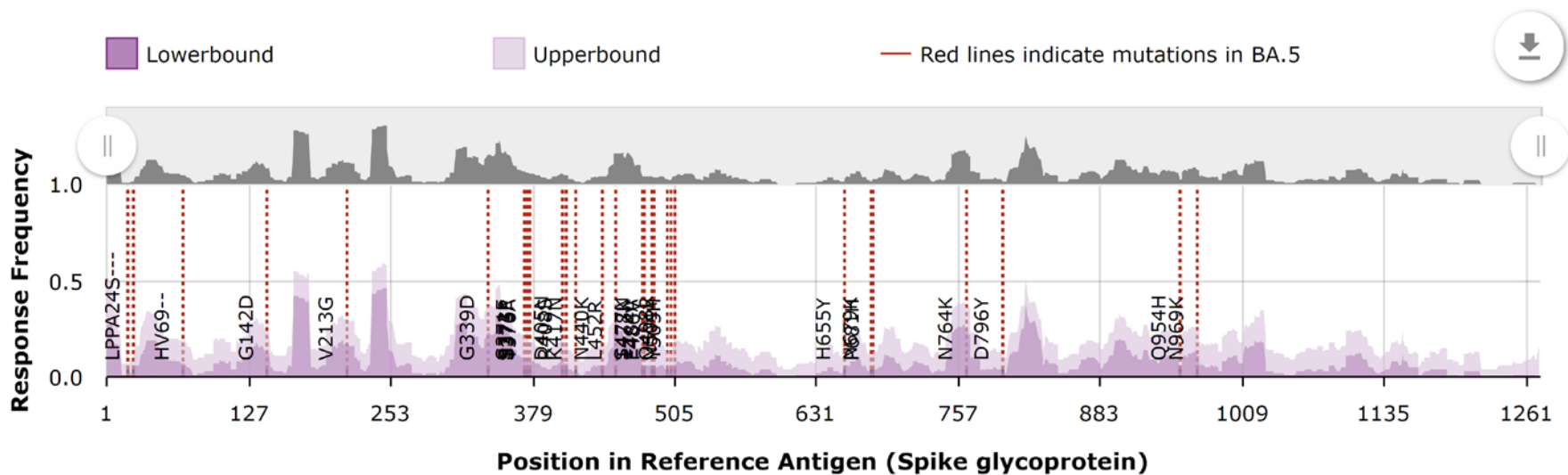
# How to use ImmunomeBrowser to define spike T cell immunodominant regions



## CD4 Immunobrowser: Spike



### Response Frequency



# ....Science is teamwork

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