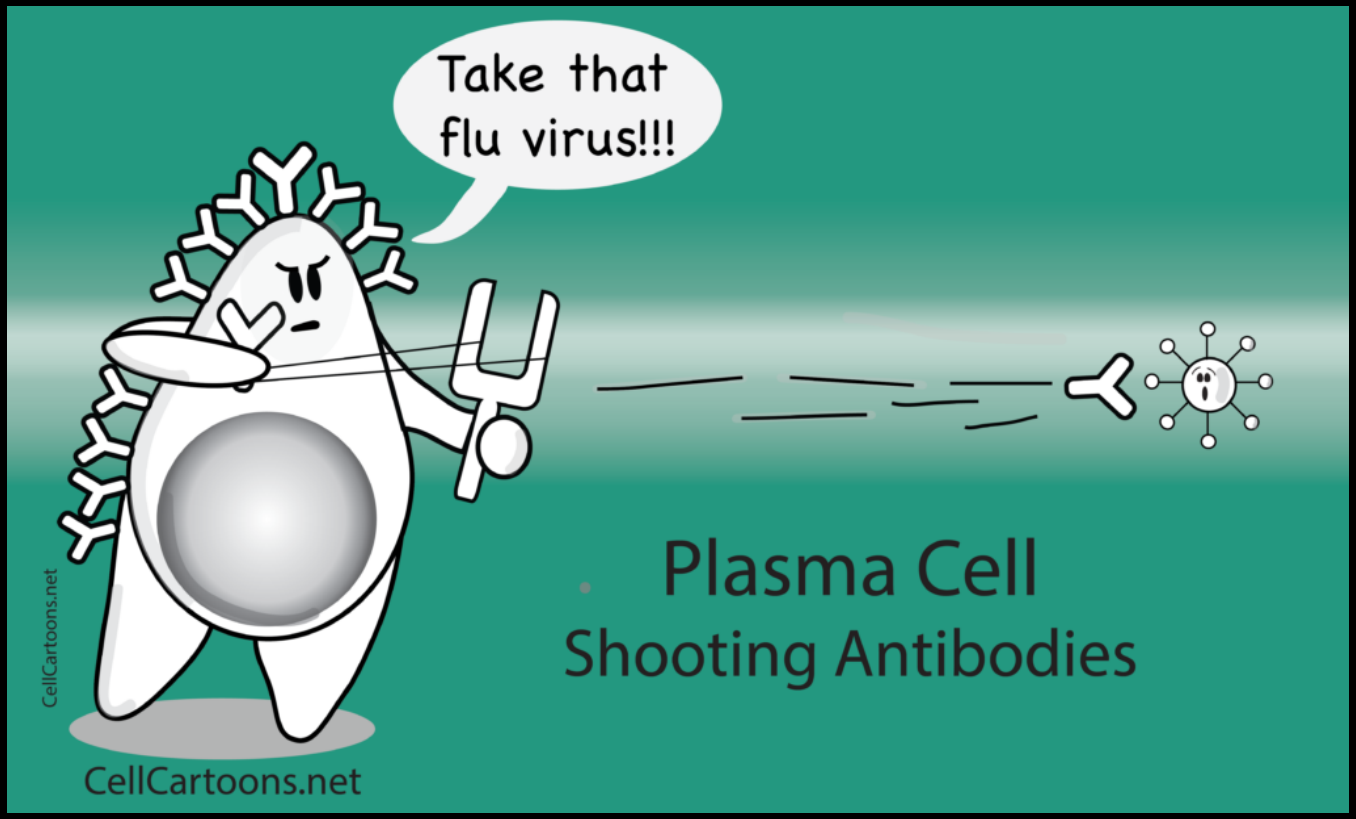
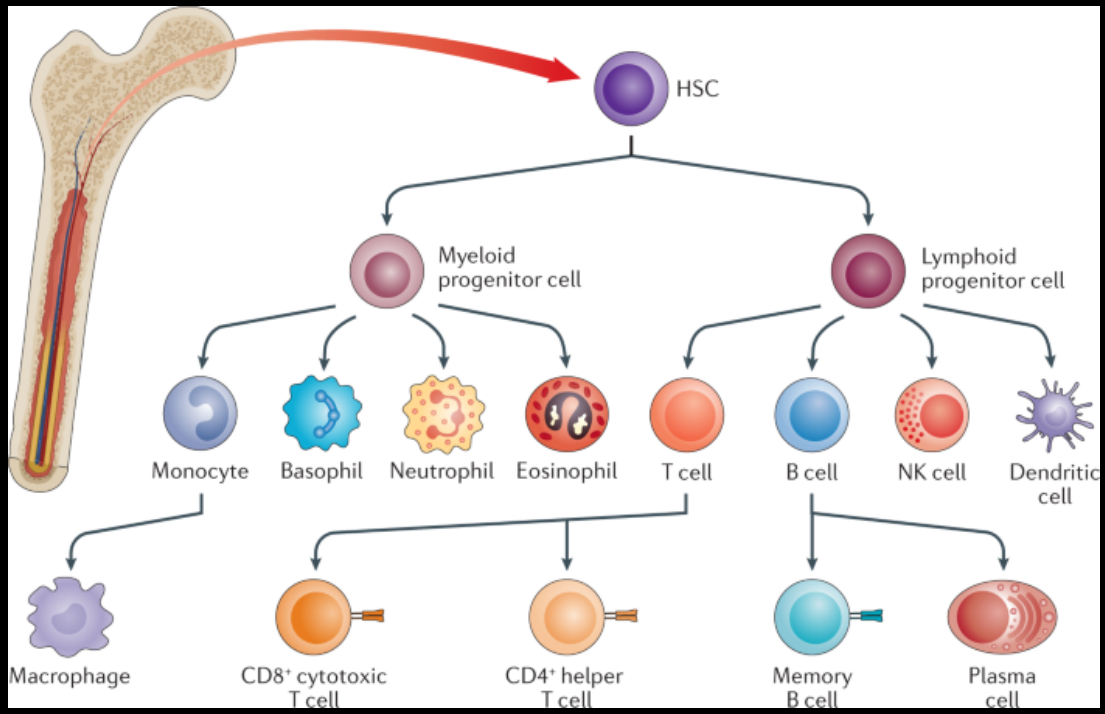
How do antibodies work?

Galit Alter

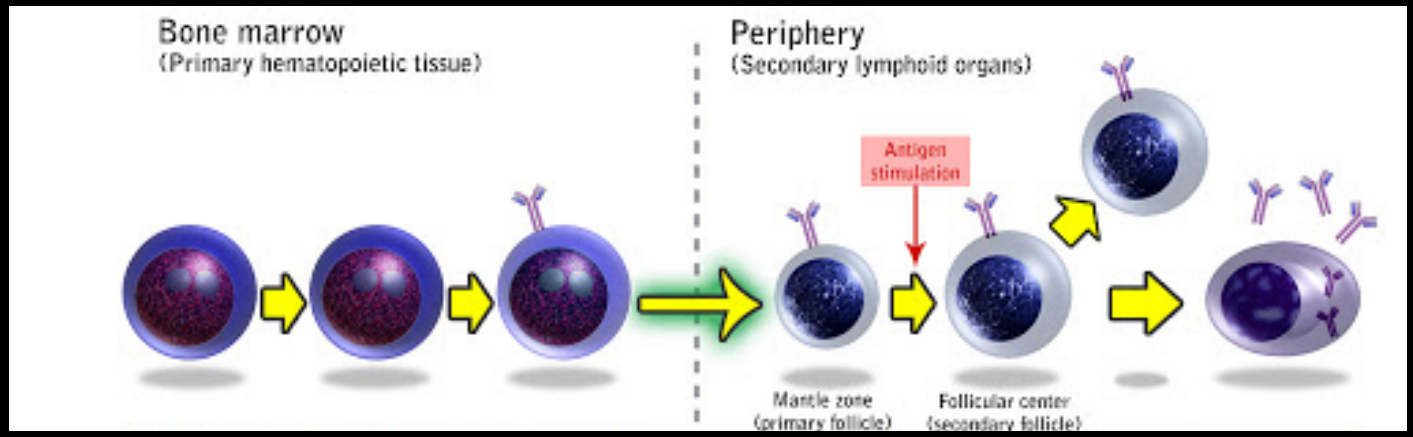
Ragon Institute


Take that flu virus!!!
Plasma Cell
Shooting Antibodies
CellCartoons.net
CellCartoons.net

Antibodies come from B cells

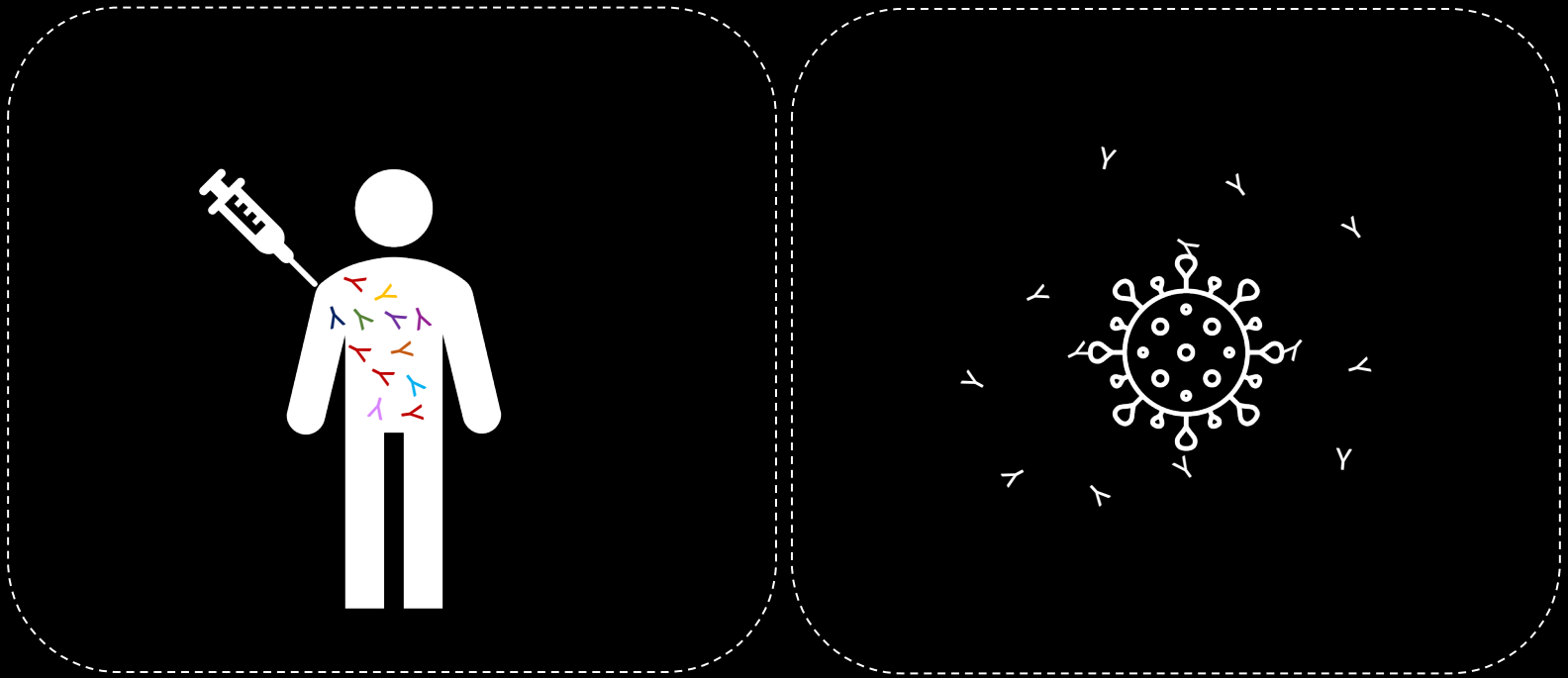


The maturation of the B cell

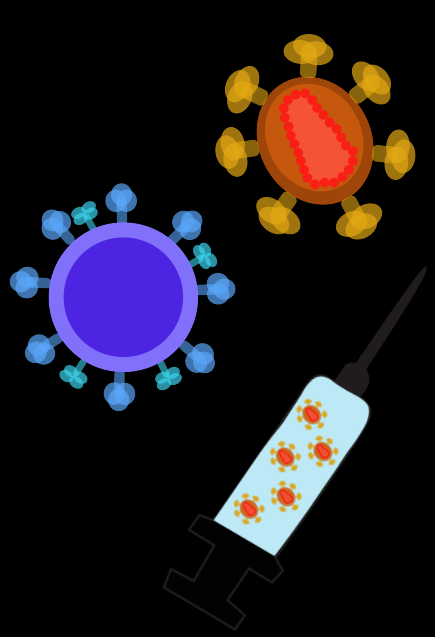


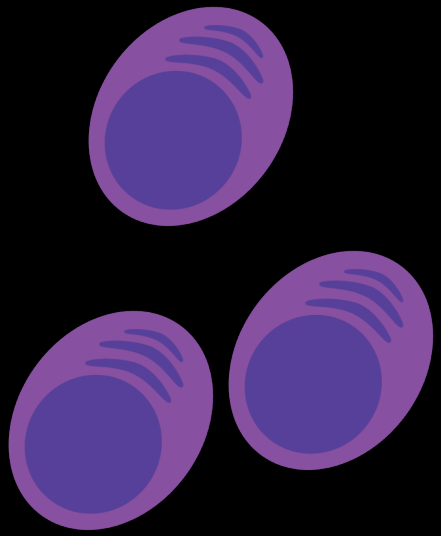
http://hematologyoutlines.com/atlas_topics/69.html

Vaccines and infection lead to the production of antibodies

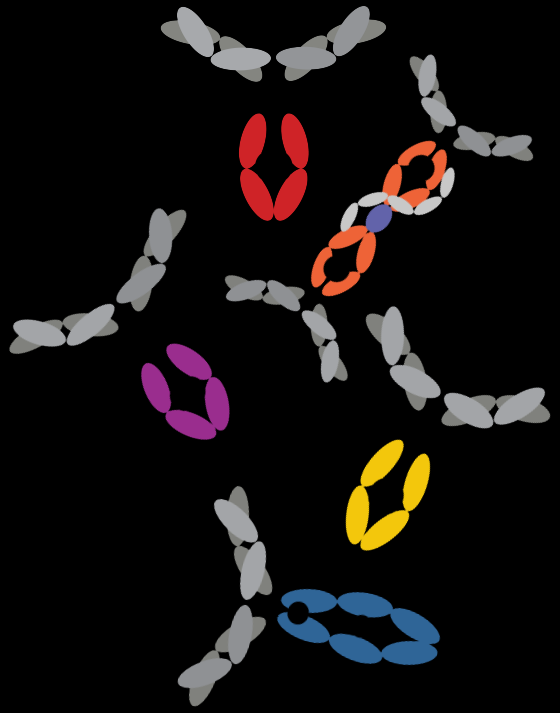


Antibodies are produced by antibody secreting cells and come in different structures and qualities

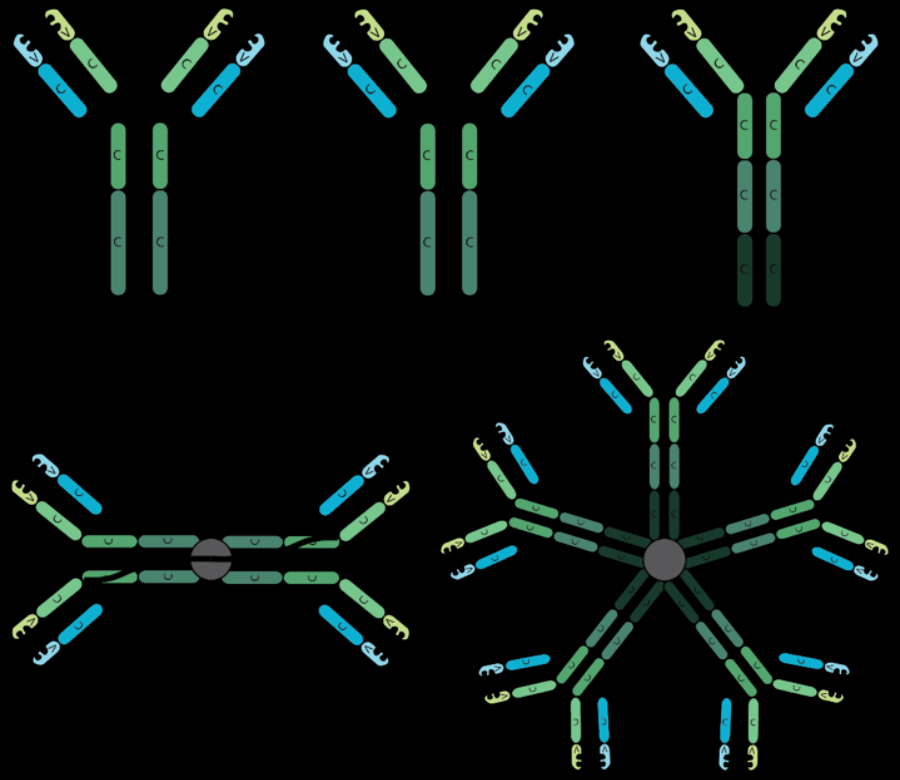




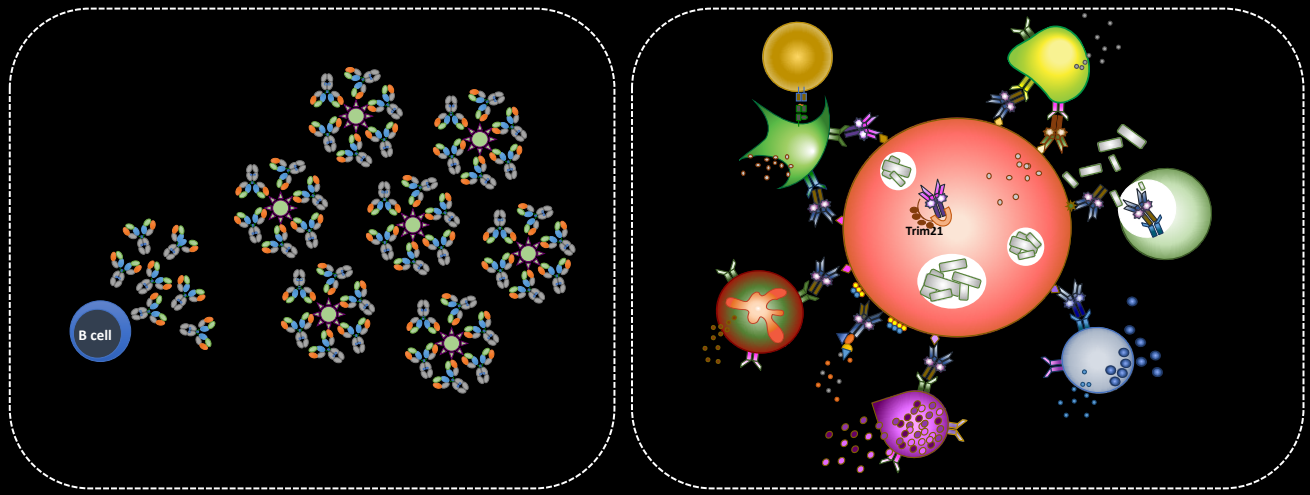
Antibody secreting cells



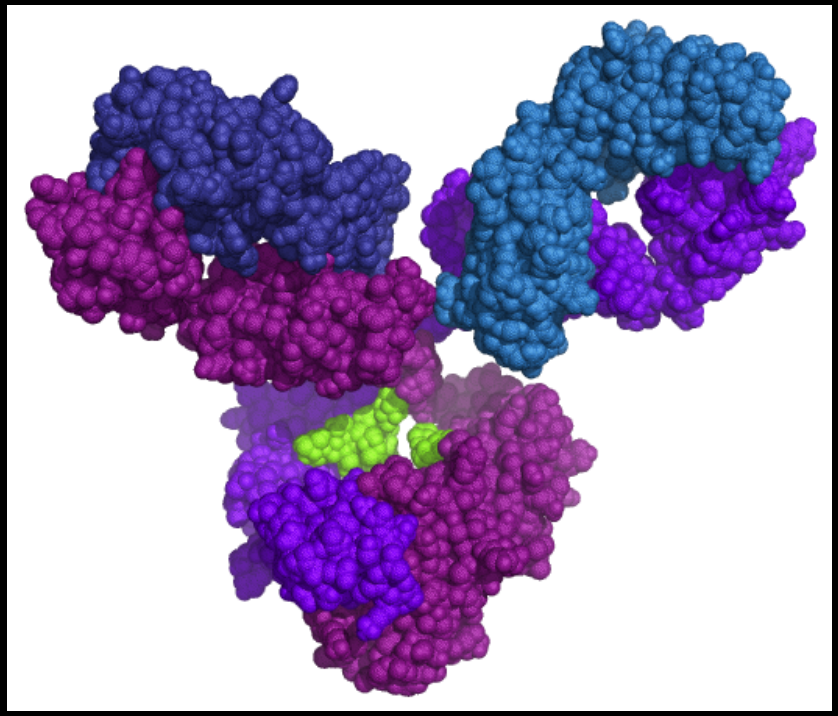
Different flavors of antibodies



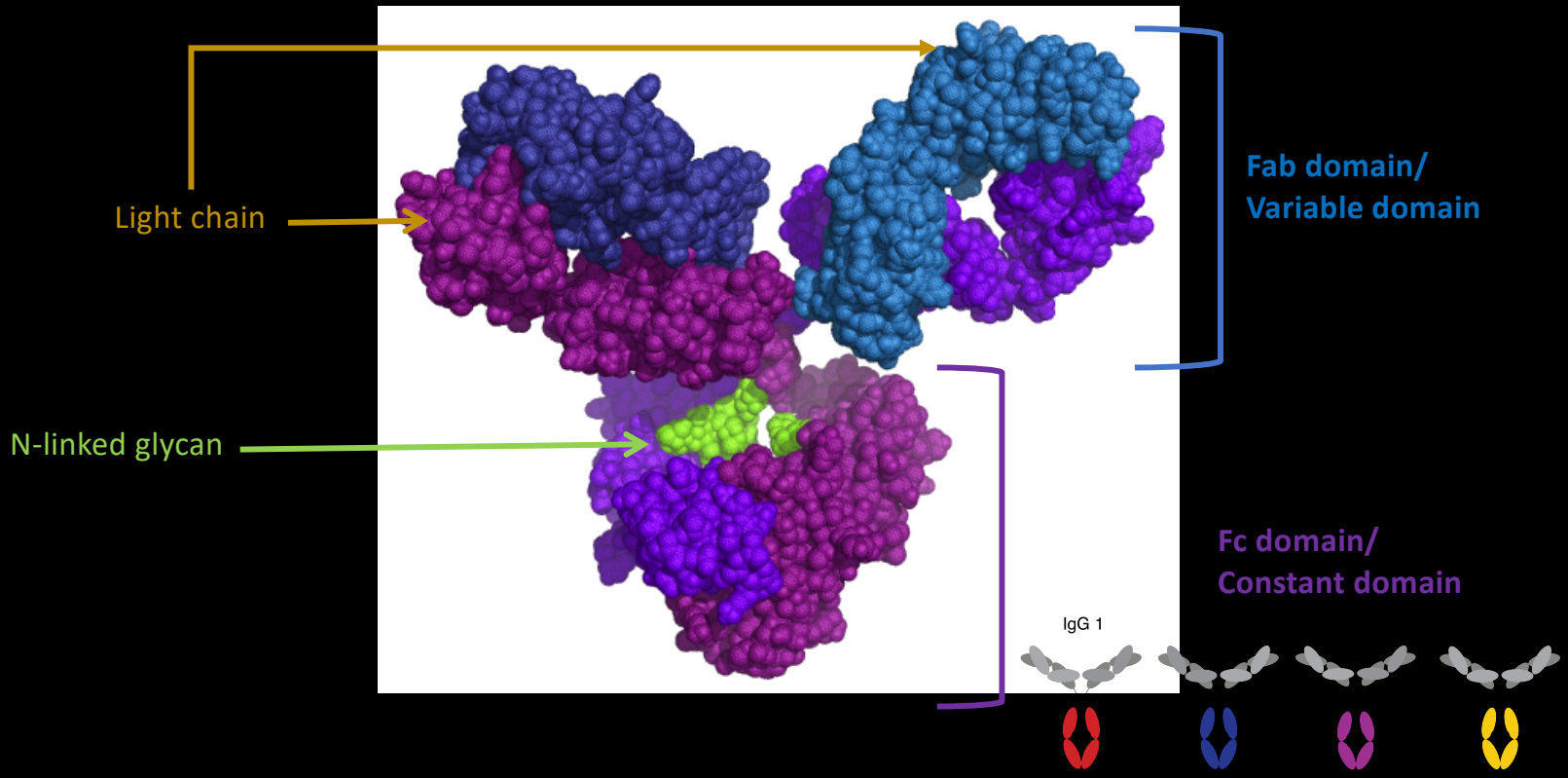
Antibodies can provide protection directly and indirectly



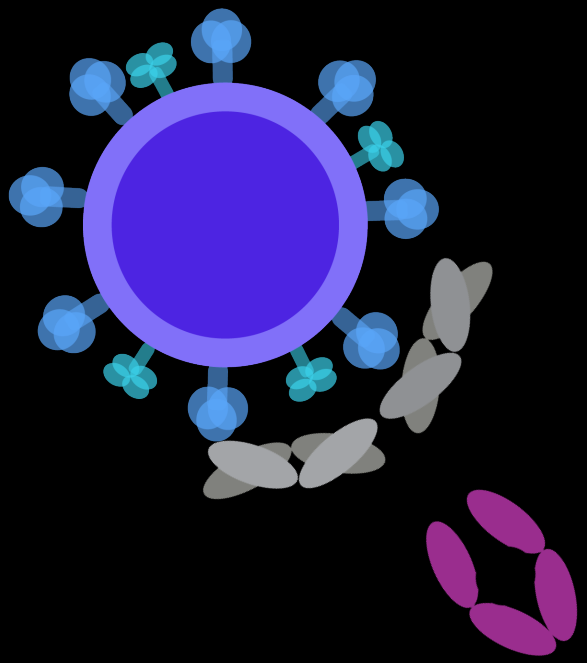
Antibody anatomy

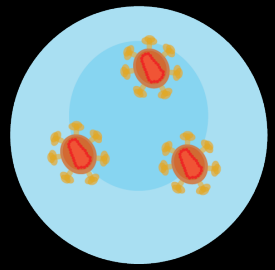


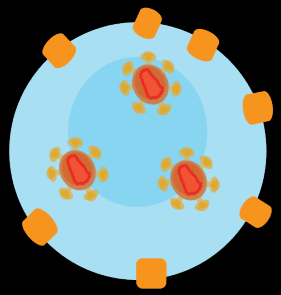
Antibody architecture

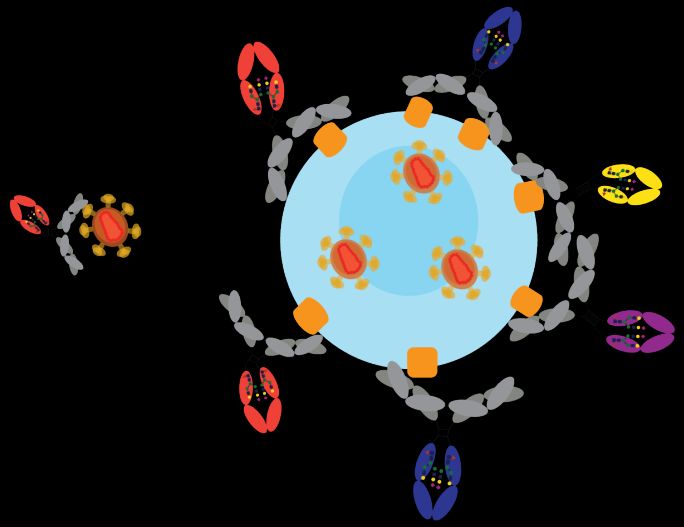


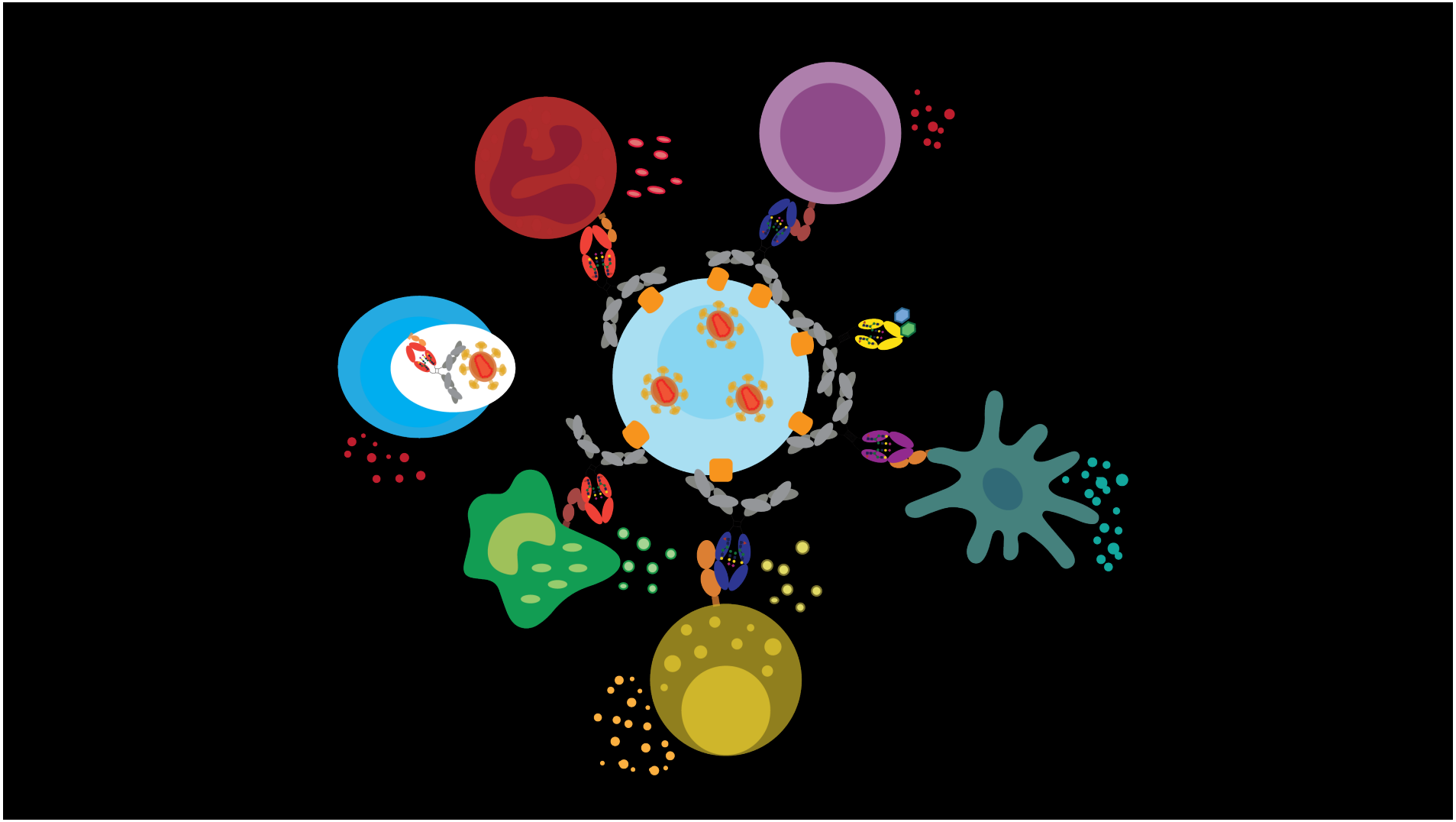
Antibodies bind and neutralize viruses



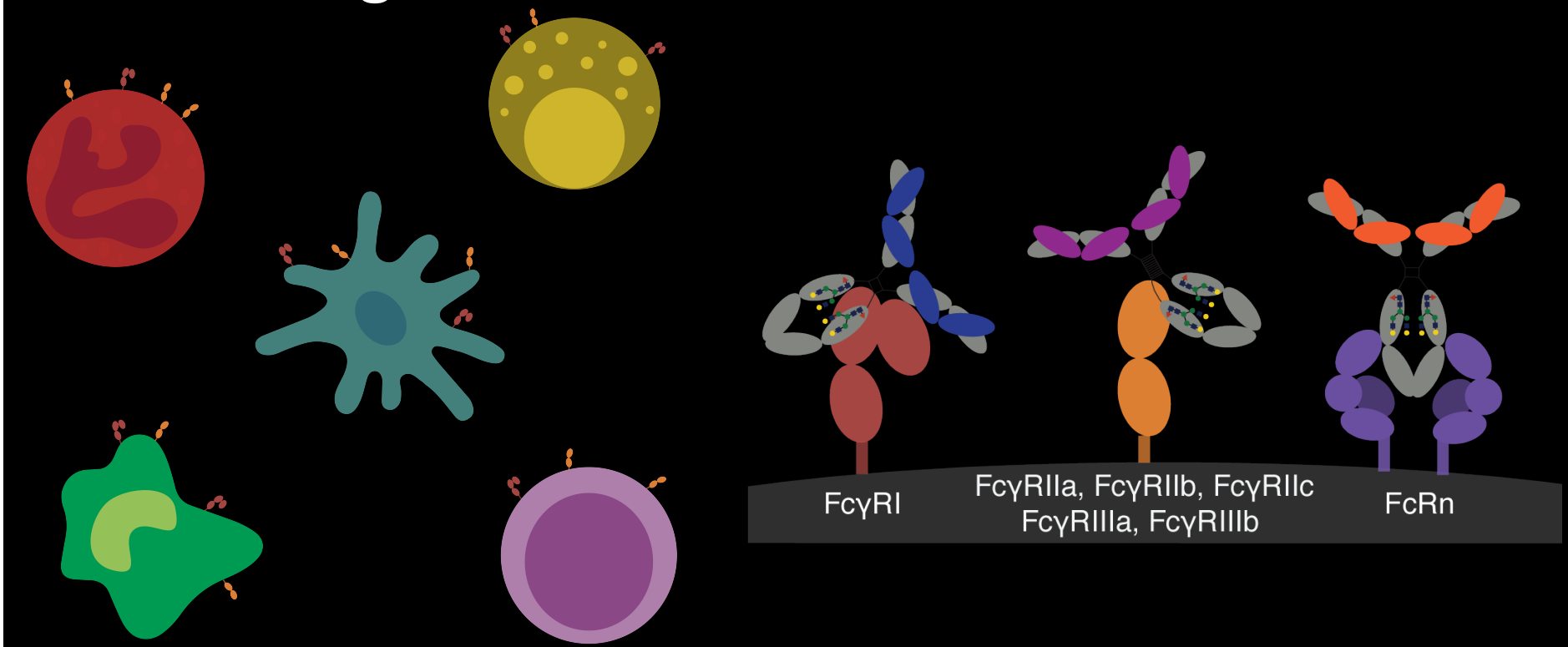




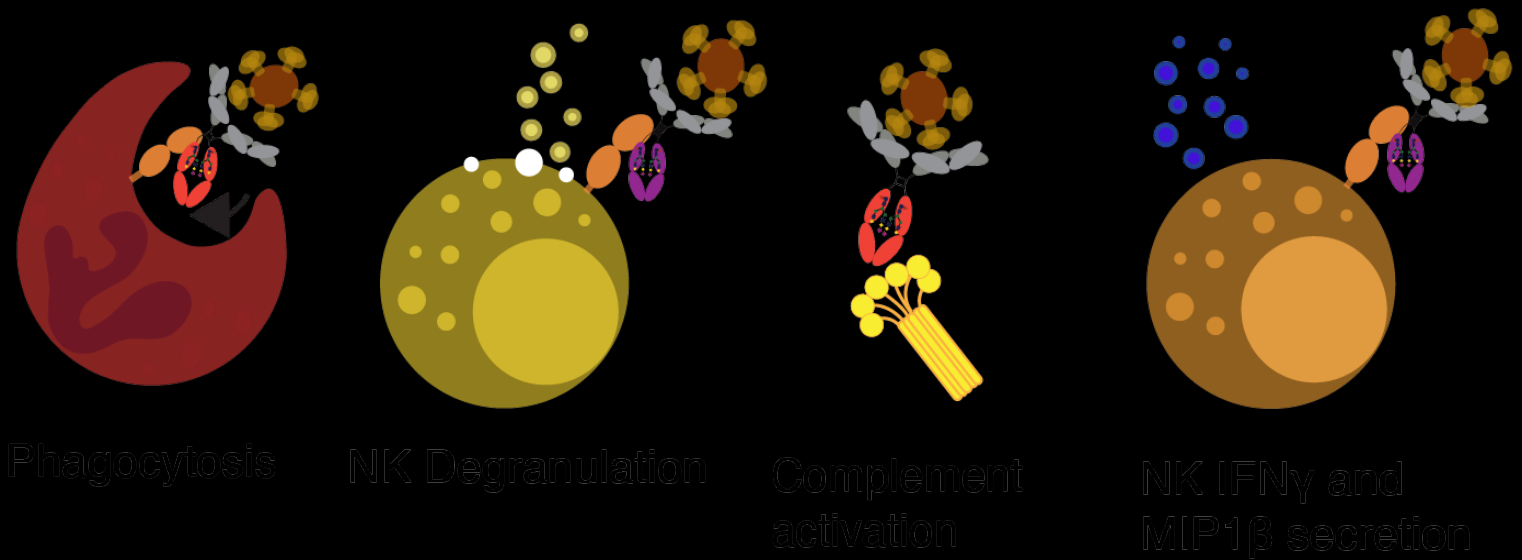




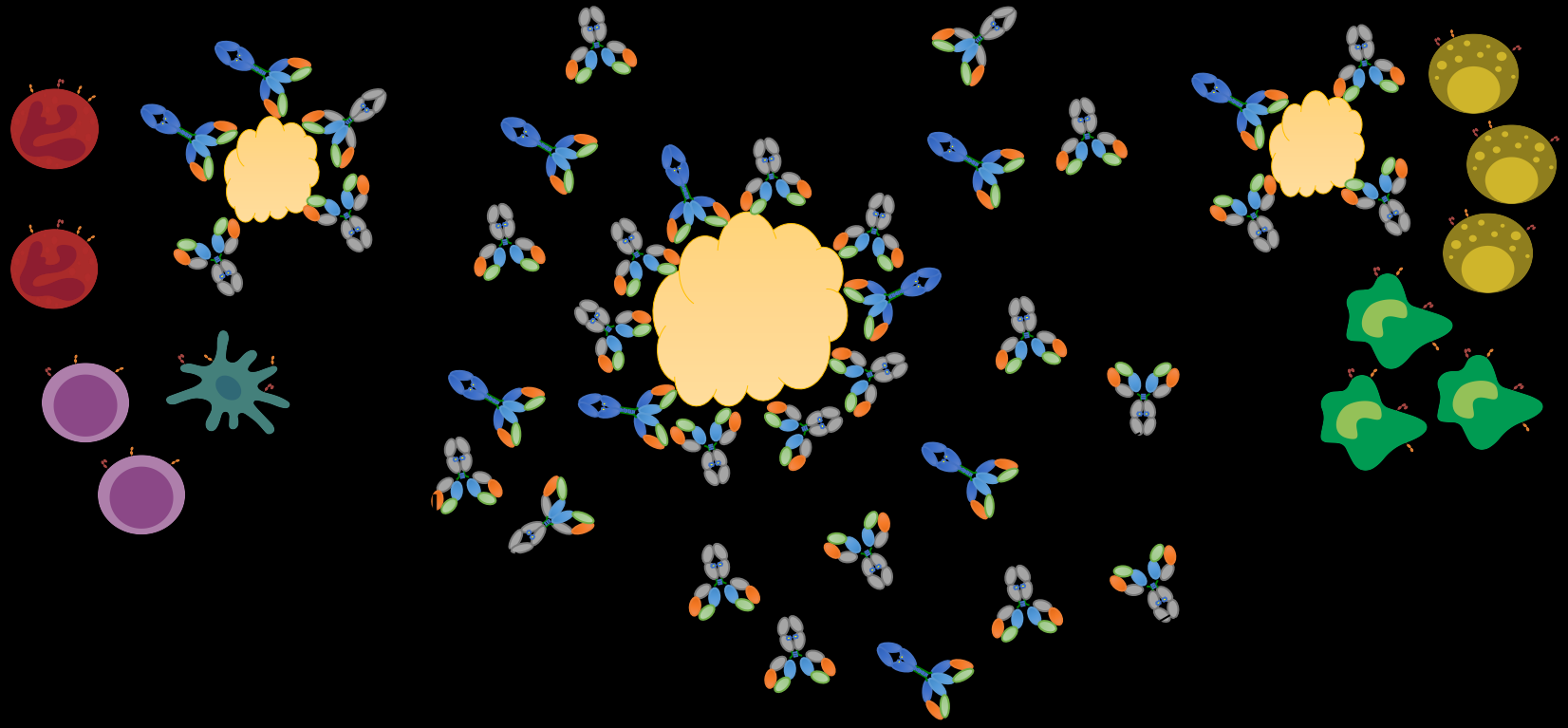
Antibodies recruit the innate immune system to direct killing



Antibodies recruit the innate immune system to direct killing



Antibodies act as swarms



Kinetics of the antibody response

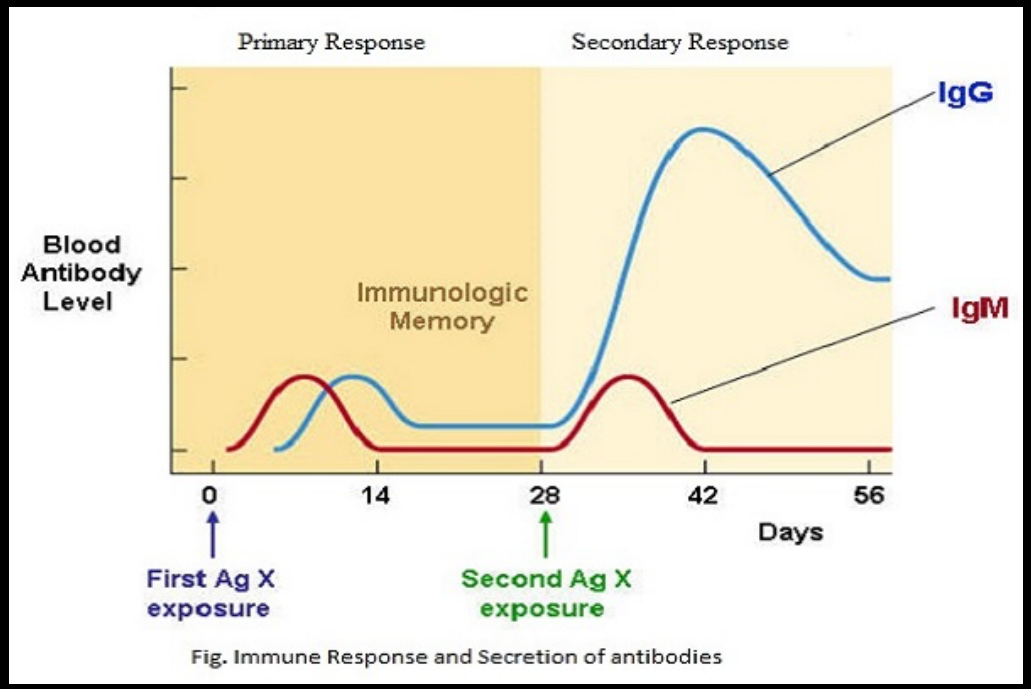
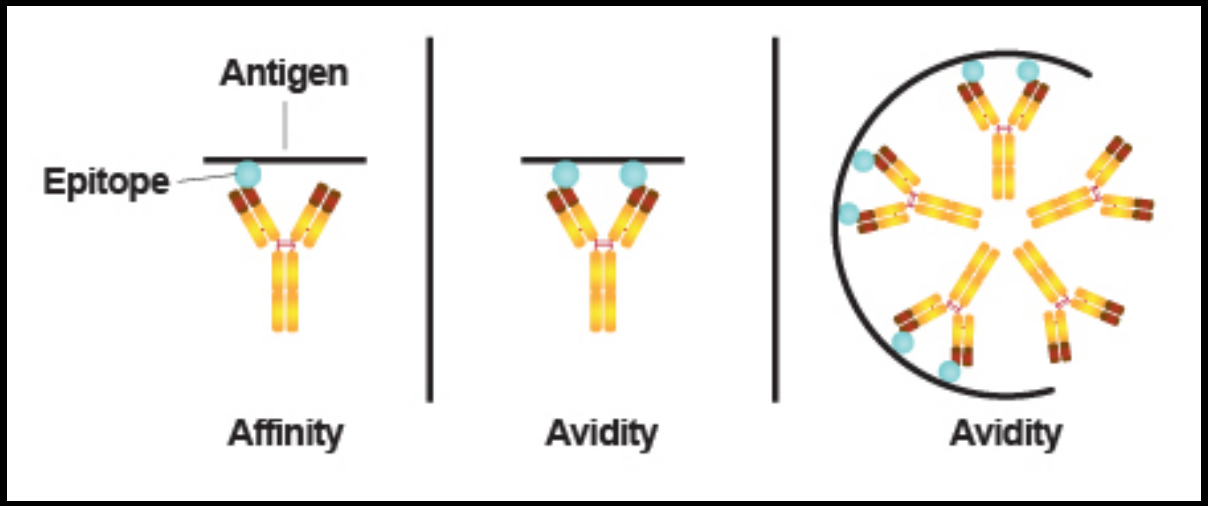
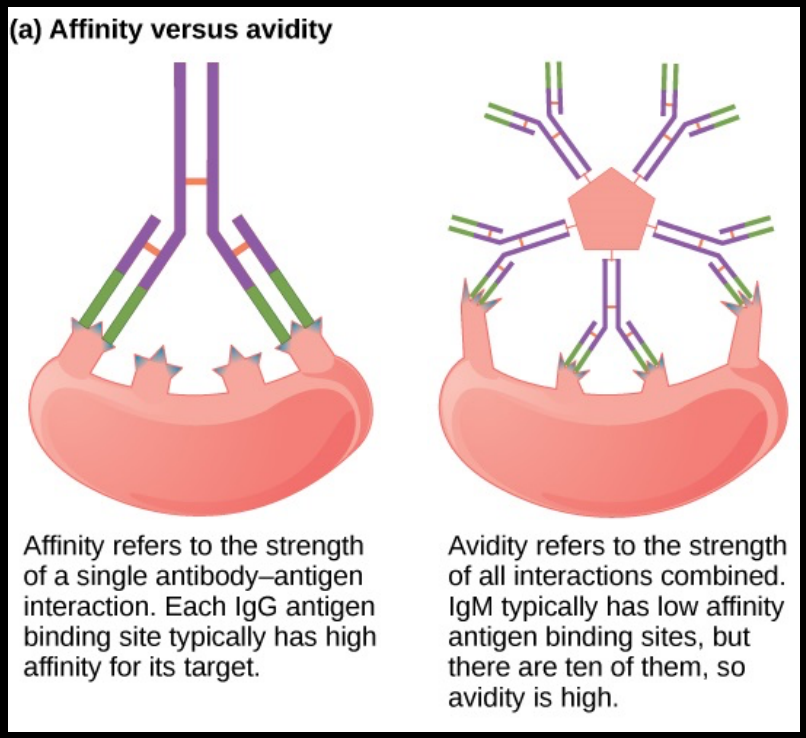


Fig. Immune Response and Secretion of antibodies

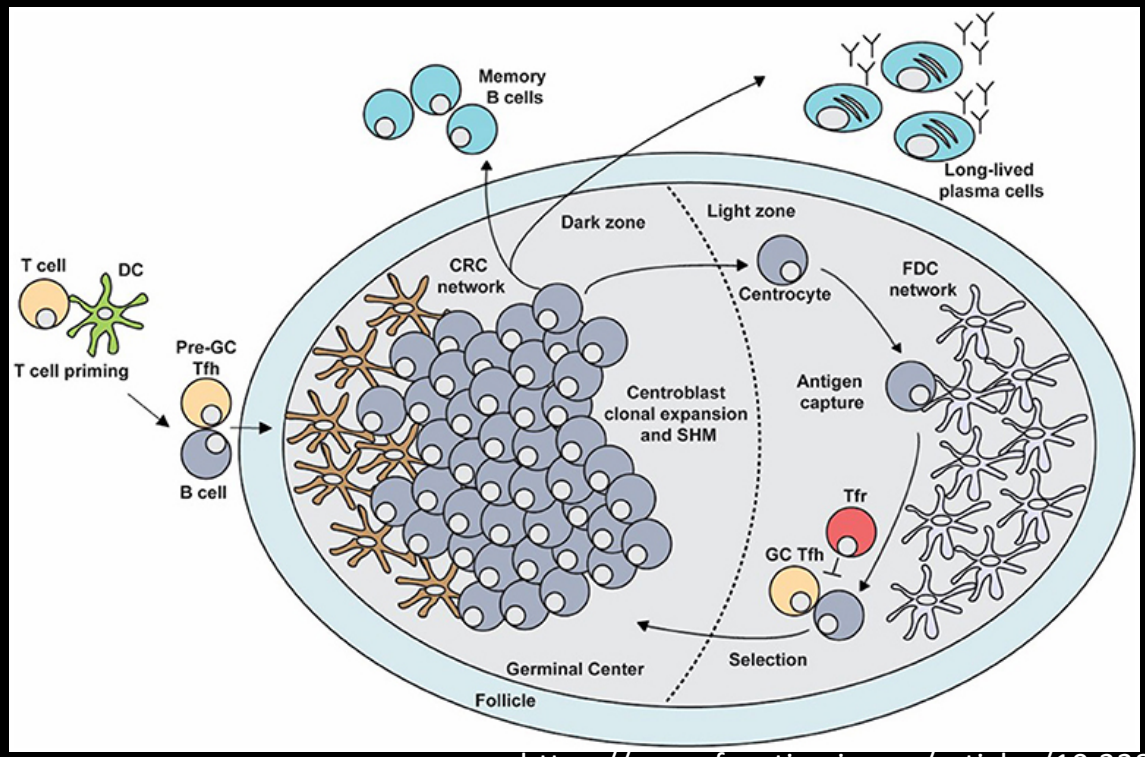
Advantage in numbers



Avidity before affinity…

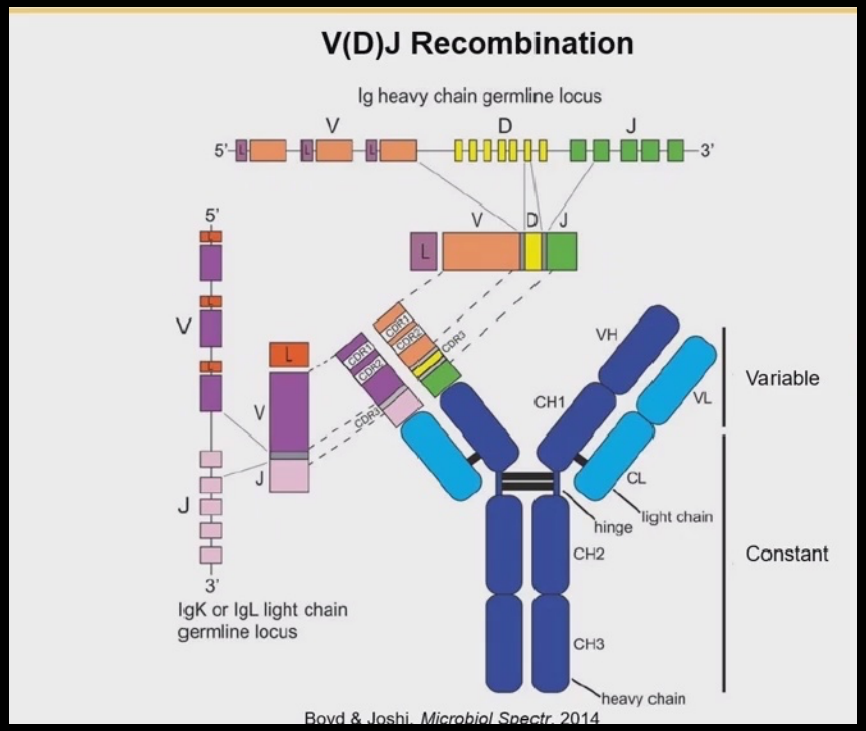


Somatic hypermutation and clonal selection

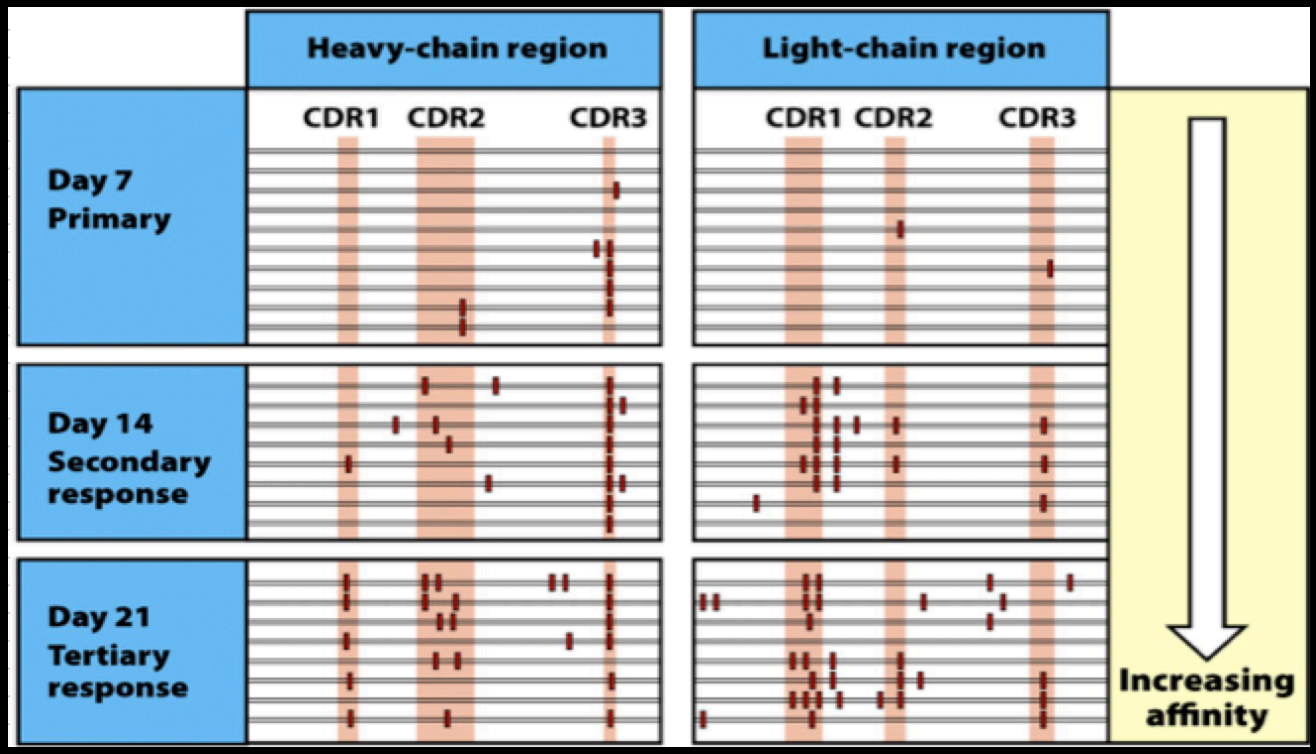


https://www.frontiersin.org/articles/10.3389/fimmu.2018.02469/full

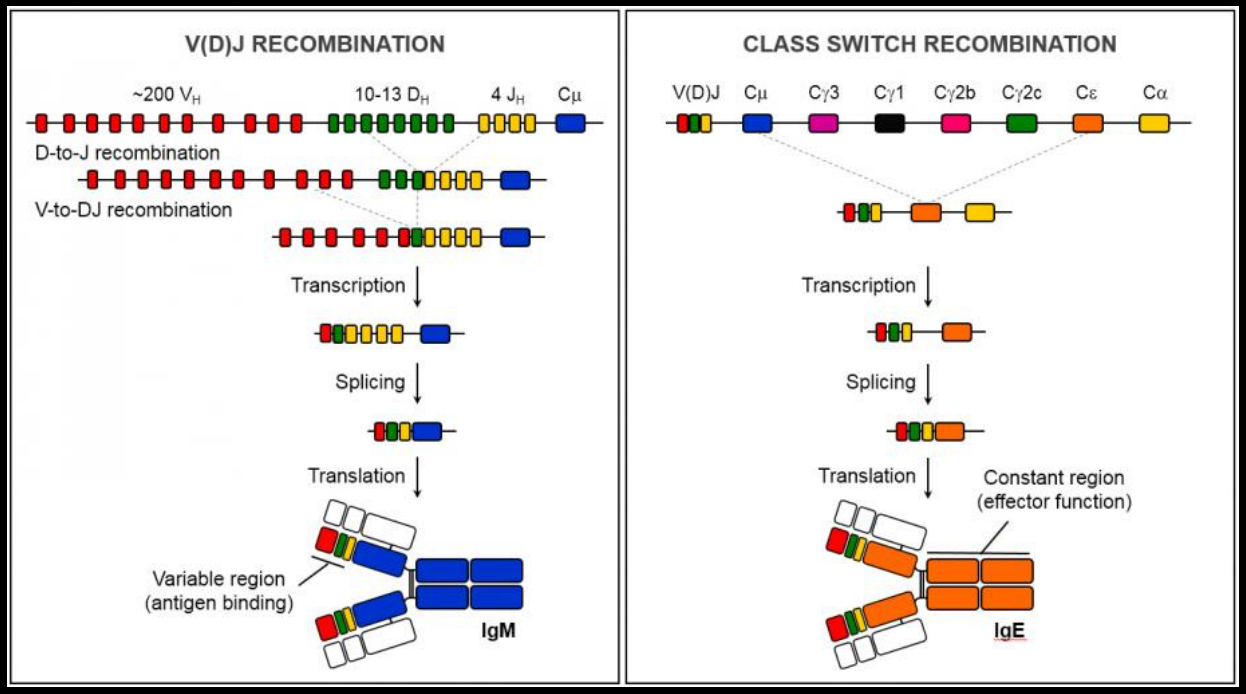
Generating diversity



Affinity maturation



Making a B-cell receptor



Antibodies as drugs

Fastest growing class of drugs…

Begelomab[6]		mab	mouse	DPP4		?
Belantamab mafodotin[5]	Blenrep	mab	humanized	B-cell maturation antigen (BCMA)	Y	relapsed or refractory multiple myeloma
Belimumab[27]	Benlysta	mab	human	B-cell activating factor (BAFF)	Y	systemic lupus erythematosus without renal or CNS involvement
Bemarituzumab[23]		mab	humanized	FGFR2		gastric cancer or gastroesophageal junction adenocarcinoma
Benralizumab[28]	Fasenra	mab	humanized	CD125	Y	asthma
Berlimatoxumab[23]		mab	human	*Staphylococcus aureus* bi-component leukocidin		?
Bermekimab[26]	Xilonix	mab	human	IL1A		colorectal cancer
Bersanlimab[5]		mab	human	ICAM-1		?
Bertilimumab[21]		mab	human	CCL11 (eotaxin-1)		severe allergic disorders
Besilesomab[29]	Scintimun	mab	mouse	Carcinoembryonic antigen (CEA)-related antigen		inflammatory lesions and metastases (detection)
Bevacizumab[12]	Avastin	mab	humanized	VEGF-A	Y	metastatic cancer, retinopathy of prematurity
Bezlotoxumab[26]	Zinplava	mab	human	*Clostridium difficile*	Y	*Clostridium difficile* colitis
Biciromab[26]	FibriScint	Fab'	mouse	fibrin II, beta chain		thromboembolism (diagnosis)
Bimagrumab[30]		mab	human	ACVR2B		myostatin inhibitor
Bimekizumab[9]		mab	humanized	IL 17A and IL 17F		ankylosing spondylitis, psoriasis
Birtamimab		mab	chimeric	serum amyloid A protein		amyloidosis
Bivatuzumab[26]		mab	humanized	CD44 v6		squamous cell carcinoma
Bleselumab[10]		mab	human	CD40		organ transplant rejection
Blinatumomab[26]	Blincyto	BiTE	mouse	CD19	Y	pre-B Acute lymphoblastic leukemia (ALL) (CD19+)
Blontuvetmab[31]	Blontress	mab	veterinary	CD20		
Blosozumab[32]		mab	humanized	SOST		osteoporosis
Bococizumab[26]		mab	humanized	PCSK9		dyslipidemia
Brazikumab[16]		mab	human	IL23		Crohn's disease
Brentuximab vedotin[26]	Adcentris	mab	chimeric	CD30 (TNFRSF8)	Y	Hodgkin's lymphoma anaplastic large-cell lymphoma
Briakinumab[26]		mab	human	IL-12, IL-23		psoriasis, rheumatoid arthritis, inflammatory bowel diseases, multiple sclerosis
Brodalumab[32]	Siliq	mab	human	IL-17	Y	Plaque psoriasis
Brolucizumab[22]	Beovu	scFv	humanized	vascular endothelial growth factor A (VEGFA)	Y	wet age-related macular degeneration
Brontictuzumab[6]		mab	humanized	Notch 1		cancer
Burosumab[16]	Crysvita	mab	human	FGF 23	Y	X-linked hypophosphatemia

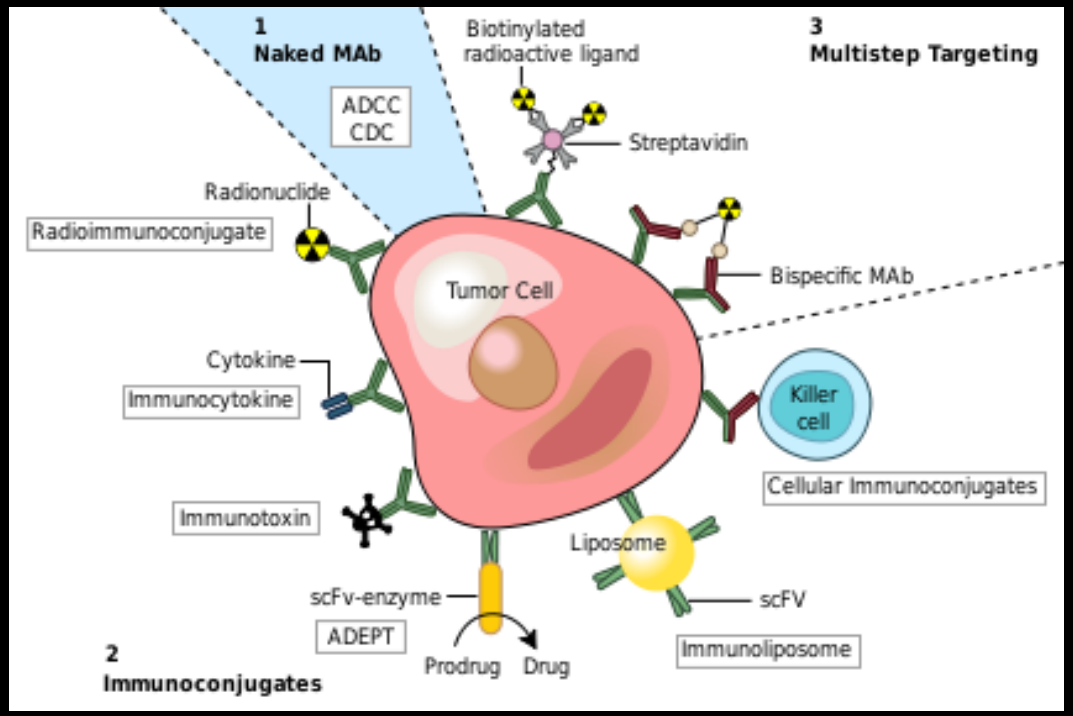
Cabiralizumab[31]		mab	humanized	CSF1R		metastatic pancreatic cancer
Camidanlumab tesirine[23]		mab	human	CD25 (α chain of IL-2 receptor)		B-cell Hodgkin's lymphoma, non-Hodgkin lymphoma, acute lymphoblastic leukemia, acute myeloid leukemia
Camrelizumab[19]		mab	humanized	PD-1		hepatocellular carcinoma
Canakinumab[33]	Ilaris	mab	human	IL-1	Y	cryopyrin-associated periodic syndrome
Cantuzumab mertansine[32]		mab	humanized	CanAg (a glycoform of MUC1)		colorectal cancer etc.
Cantuzumab ravtansine[32]		mab	humanized	CanAg (a glycoform of MUC1)		cancers
Caplacizumab[34]	Cablivi	sdAb	humanized	VWF	Y	thrombotic thrombocytopenic purpura, thrombosis
Capromab[26]	Prostascint	mab	mouse	Glutamate carboxypeptidase II	Y	prostate cancer (detection)
Carlumab[14]		mab	human	MCP-1		oncology/immune indications
Carotuximab[31]		mab	chimeric	endoglin		angiosarcoma
Catumaxomab[25]	Removab	3funct	rat/mouse hybrid	EpCAM, CD3	Y	ovarian cancer, malignant ascites, gastric cancer
cBR96-doxorubicin immunoconjugate		mab	humanized	Lewis-Y antigen		cancer
Cedelizumab[35]		mab	humanized	CD4		prevention of organ transplant rejections, treatment of autoimmune diseases
Cemiplimab[26]	Libtayo	mab	human	PDCD1	Y	cutaneous squamous cell carcinoma
Cergutuzumab amunaleukin[10]		mab	humanized	IL2		cancer
Certolizumab pegol[33]	Cimzia	Fab'	humanized	TNF-α	Y	Crohn's disease, rheumatoid arthritis, axial spondyloarthritis, psoriasis arthritis
Cetrelimab[5]		mab	human	PD-1		cancer
Cetuximab[26]	Erbitux	mab	chimeric	Epidermal growth factor receptor (EGFR)	Y	metastatic colorectal cancer and head and neck cancer
Cibisatamab[5]		mab	humanized	CEACAM5		cancer
Cirmtuzumab[28]		?	humanized	ROR1		chronic lymphocytic leukemia
Citatuzumab bogatox[36]		Fab	humanized	EpCAM		ovarian cancer and other solid tumors
Cixutumumab[26]		mab	human	IGF-1 receptor (CD221)		solid tumors
Clazakizumab[37]		mab	humanized	interleukin 6 (IL-6)		rheumatoid arthritis
Clenoliximab[26]		mab	chimeric	CD4		rheumatoid arthritis
Clivatuzumab tetraxetan[26]	hPAM4-Cide	mab	humanized	MUC1		pancreatic cancer
Codrituzumab[4]		mab	humanized	glypican 3		cancer
Cofetuzumab pelidotin[23]		mab	humanized	PTK7		cancer
Coltuximab ravtansine[4]		mab	chimeric	CD19		cancer

Conatumumab[36]		mab	human	TRAIL-R2		cancer
Concizumab[30]		mab	humanized	tissue factor pathway inhibitor (TFPI)		bleeding
Cosfroviximab[24]	ZMapp	mab	chimeric	ebolavirus glycoprotein		Ebola virus
Crenezumab[26]		mab	humanized	1-40-β-amyloid		Alzheimer's disease
Crizanlizumab[19]	Adakveo	mab	humanized	selectin P	Y	sickle-cell disease
Crotedumab[31]		mab	human	glucagon receptor (GCGR)		diabetes
CR6261		mab	human	Influenza A hemagglutinin		infectious disease/influenza A
Cusatuzumab[5]		mab	humanized	CD70		cancer
Dacetuzumab[11]		mab	humanized	CD40		hematologic cancers
Daclizumab[38]	Zenapax	mab	humanized	CD25 (α chain of IL-2 receptor)	Y	prevention of organ transplant rejections, multiple sclerosis
Dalotuzumab		mab	humanized	IGF-1 receptor (CD221)		cancer etc.
Dapirolizumab pegol[9]		mab	humanized	CD154 (CD40L)		?
Daratumumab[39]	Darzalex	mab	human	CD38	Y	multiple myeloma
Dectrekumab[22]		mab	human	IL-13		?
Demcizumab		mab	humanized	DLL4		cancer
Denintuzumab mafodotin[6]		mab	humanized	CD19		cancer
Denosumab[40]	Prolia	mab	human	RANKL	Y	osteoporosis, bone metastases etc.
Depatuxizumab mafodotin[19]		mab	chimeric/humanized	EGFR		glioblastoma
Derlotuximab biotin		mab	chimeric	histone complex		recurrent glioblastoma multiforme
Detumomab		mab	mouse	B-lymphoma cell		lymphoma
Dezamizumab[19]		mab	humanized	serum amyloid P component		?
Dinutuximab	Unituxin	mab	chimeric	GD2 ganglioside	Withdrawn	neuroblastoma
Dinutuximab beta	Qarziba	mab	chimeric	GD2 ganglioside	Y	neuroblastoma
Diridavumab		mab	human	hemagglutinin		influenza A
Domagrozumab[31]		mab	humanized	GDF-8		Duchenne muscular dystrophy
Dorlimomab aritox[41]		$F(ab')_2$	mouse	?		?
Dostarlimab[42]		mab	humanized	PCDP1		cancer
Drozitumab		mab	human	DR5		cancer etc.
DS-8201		?	humanized	HER2		gastric or gastroesophageal junction adenocarcinoma
Duligotuzumab[13]		mab	humanized	ERBB3 (HER3)		testicular cancer
Dupilumab[30]	Dupixent	mab	human	IL-4Rα	Y	atopic dermatitis, asthma, nasal polyps
Durvalumab[22]	Imfinzi	mab	human	PD-L1	Y	cancer
Dusigitumab		mab	human	ILGF2		B-cell malignancies
Duvortuxizumab[24]		scFv	chimeric/humanized	CD19, CD3E		cancer

Ecromeximab[18]		mab	chimeric	GD3 ganglioside		malignant melanoma
Eculizumab[18]	Soliris	mab	humanized	C5	Y	paroxysmal nocturnal hemoglobinuria, atypical hemolytic uremic syndrome
Edobacomab		mab	mouse	endotoxin		sepsis caused by Gram-negative bacteria
Edrecolomab	Panorex	mab	mouse	EpCAM		colorectal carcinoma
Efalizumab[7]	Raptiva	mab	humanized	LFA-1 (CD11a)		psoriasis (blocks T-cell migration)
Efungumab[2]	Mycograb	scFv	human	Hsp90		invasive *Candida* infection
Eldelumab[4]		mab	human	interferon gamma-induced protein		Crohn's disease, ulcerative colitis
Elezanumab[19]		mab	human	repulsive guidance molecule A (RGMA)		spinal cord injury and multiple sclerosis
Elgemtumab[22]		mab	human	ERBB3 (HER3)		cancer
Elotuzumab	Empliciti	mab	humanized	SLAMF7	Y	multiple myeloma
Elsilimomab		mab	mouse	IL-6		?
Emactuzumab[6]		mab	humanized	CSF1R		cancer
Emapalumab[19]	Gamifant	mab	human	interferon gamma	Y	hemophagocytic lymphohistiocytosis
Emibetuzumab		mab	humanized	hHGFR		cancer
Emicizumab[10]	Hemlibra	mab	humanized	activated F9, F10	Y	haemophilia A
Enapotamab vedotin[5]		mab	human	AXL		cancer
Enavatuzumab		mab	humanized	TWEAK receptor		cancer etc.
Enfortumab vedotin	Padcev	mab	human	nectin-4	Y	urothelial cancer
Enlimomab pegol[43]		mab	mouse	ICAM-1 (CD54)		?
Enoblituzumab[19]		mab	humanized	CD276		cancer
Enokizumab		mab	humanized	IL9		asthma
Enoticumab[13]		mab	human	DLL4		?
Ensituximab		mab	chimeric	MUC5AC		cancer
Epitumomab cituxetan[44]		mab	mouse	episialin		?
Epratuzumab		mab	humanized	CD22		cancer, systemic lupus erythematosus (SLE)
Eptinezumab[19]	Vyepti	mab	humanized	calcitonin gene-related peptide	Y	migraine
Erenumab[19]	Aimovig	mab	human	calcitonin gene-related peptide receptor (CGRP)	Y	migraine
Erlizumab[45]		$F(ab')_2$	humanized	ITGB2 (CD18)		heart attack, stroke, traumatic shock
Ertumaxomab[25]	Rexomun	3funct	rat/mouse hybrid	HER2/neu, CD3	Y	breast cancer etc.
Etaracizumab	Abegrin	mab	humanized	integrin $\alpha_v\beta_3$	Y	melanoma, prostate cancer, ovarian cancer etc.
Etigilimab[5]		mab	humanized	TIGIT		?
Etrolizumab[14]		mab	humanized	integrin β_7		inflammatory bowel disease
Evinacumab		mab	human	angiopoietin 3		dyslipidemia

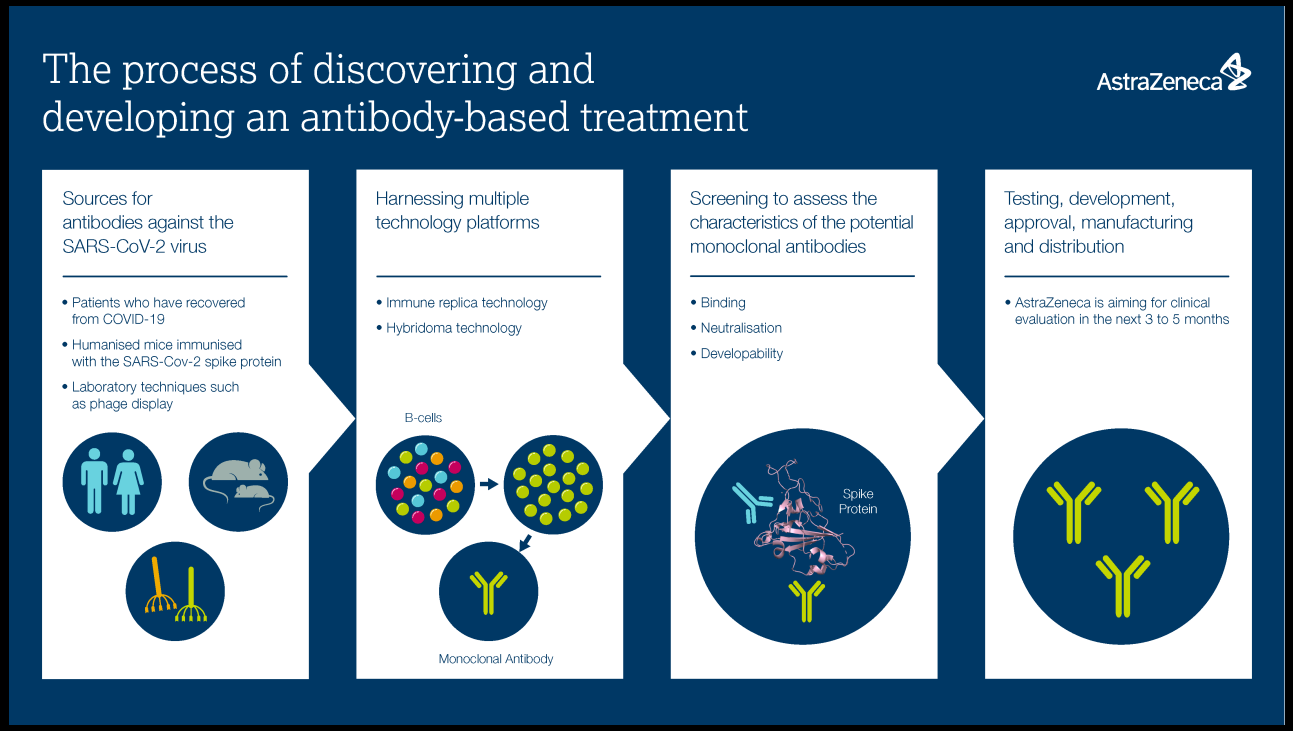
		mab	human			Alzheimer's disease
Gatipotuzumab[24]		mab	humanized	MUC1		cancer
Gavilimomab[45]		mab	mouse	CD147 (basigin)		graft versus host disease
Gedivumab[24]		mab	human	hemagglutinin HA		?
Gemtuzumab ozogamicin[19]	Mylotarg	mab	humanized	CD33	Y	acute myelogenous leukemia
Gevokizumab		mab	humanized	IL-1β		diabetes etc.
Gilvetmab[24]		mab	veterinary	PCDC1		?
Gimsilumab[23]		mab	human	CSF2		rheumatoid arthritis
Girentuximab[39]	Rencarex	mab	chimeric	carbonic anhydrase 9 (CA-IX)		clear cell renal cell carcinoma[52]
Glembatumumab vedotin[28][53]		mab	human	GPNMB		melanoma, breast cancer
Golimumab[46]	Simponi	mab	human	TNF-α	Y	rheumatoid arthritis, psoriatic arthritis, ankylosing spondylitis
Gomiliximab		mab	chimeric	CD23 (IgE receptor)		allergic asthma
Gosuranemab		mab	humanized	tau protein		progressive supranuclear palsy
Guselkumab	Tremfya	mab	human	IL23	Y	psoriasis
Ianalumab[23]		mab	human	BAFF-R		autoimmune hepatitis
Ibalizumab[33]	Trogarzo	mab	humanized	CD4	Y	HIV infection
IBI308		?	human	PD-1		squamous cell non-small cell lung cancer
Ibritumomab tiuxetan	Zevalin	mab	mouse	CD20	Y	non-Hodgkin's lymphoma
Icrucumab		mab	human	VEGFR-1		cancer etc.
Idarucizumab[4]	Praxbind	mab	humanized	dabigatran	Y	reversal of anticoagulant effects of dabigatran
Ifabotuzumab[19]		mab	humanized	EPHA3		glioblastoma multiforme[54]
Igovomab	Indimacis-125	$F(ab')_2$	mouse	CA-125		ovarian cancer (diagnosis)
Iladatuzumab vedotin[23]		mab	humanized	CD79B		cancer
IMAB362		mab	human	CLDN18.2		gastrointestinal adenocarcinomas and pancreatic tumor
Imalumab[6]		mab	human	macrophage migration inhibitory factor (MIF)		cancer
Imaprelimab[5]		mab	humanized	melanoma cell adhesion molecule (MCAM)		?
Imciromab	Myoscint	mab	mouse	cardiac myosin	Y	cardiac imaging
Imgatuzumab[13]		mab	humanized	Epidermal growth factor receptor (EGFR)		cancer
Inclacumab[34]		mab	human	selectin P		cardiovascular disease
Indatuximab ravtansine[32]		mab	chimeric	SDC1		cancer
Indusatumab vedotin[22]		mab	human	GUCY2C		cancer
Inebilizumab[10]	Uplizna	mab	humanized	CD19	Y	cancer, systemic sclerosis,

Ways antibodies are used as drugs

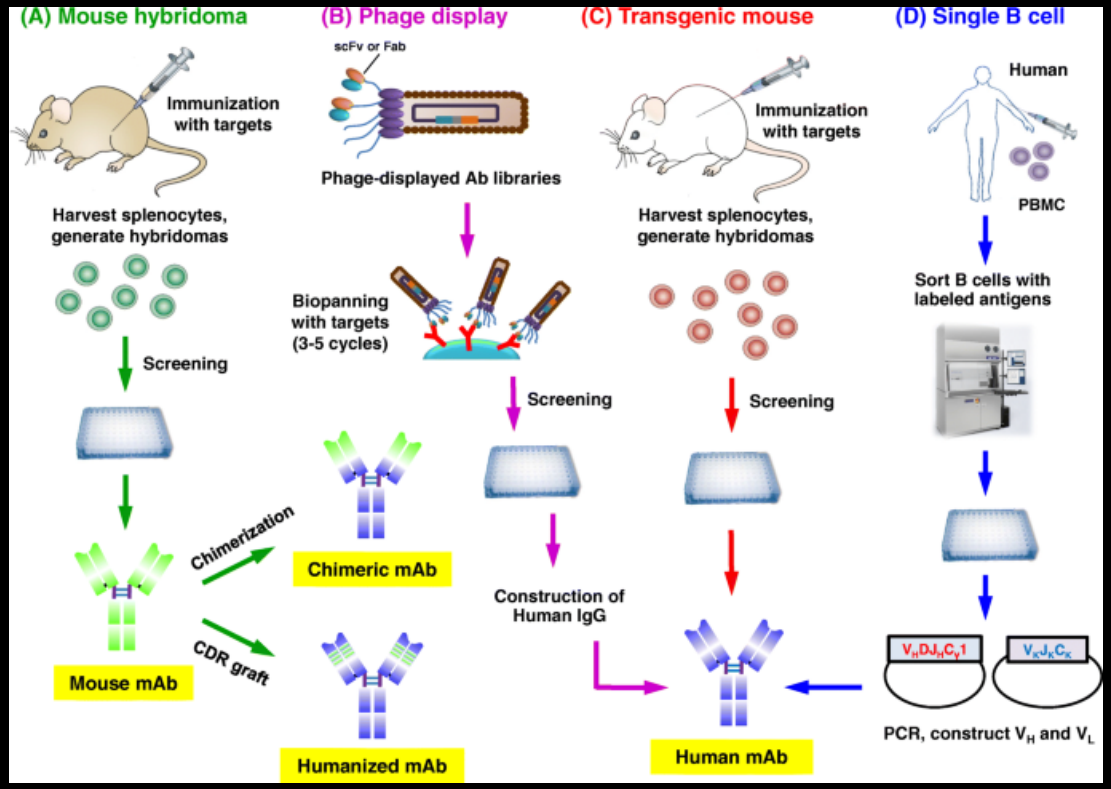


https://en.wikipedia.org/wiki/Monoclonal_antibody

Antibody drug discovery process



Deeper view of discovery process…



https://jbiomedsci.biomedcentral.com/articles/10.1186/s12929-019-0592-z

The Lilly COVID antibody drug

Lilly announces proof of concept data for neutralizing antibody LY-CoV555 in the COVID-19 outpatient setting

September 16, 2020

- Primary endpoint of viral load change from baseline at day 11 was met for one of three doses; consistent effects of viral reduction seen at earlier time points

Download PDF

- Rate of hospitalizations and ER visits was 1.7 percent (5/302) for LY-CoV555 versus 6 percent (9/150) for placebo--a 72 percent risk reduction in this limited population

The Regeneron antibody drug

REGENERON

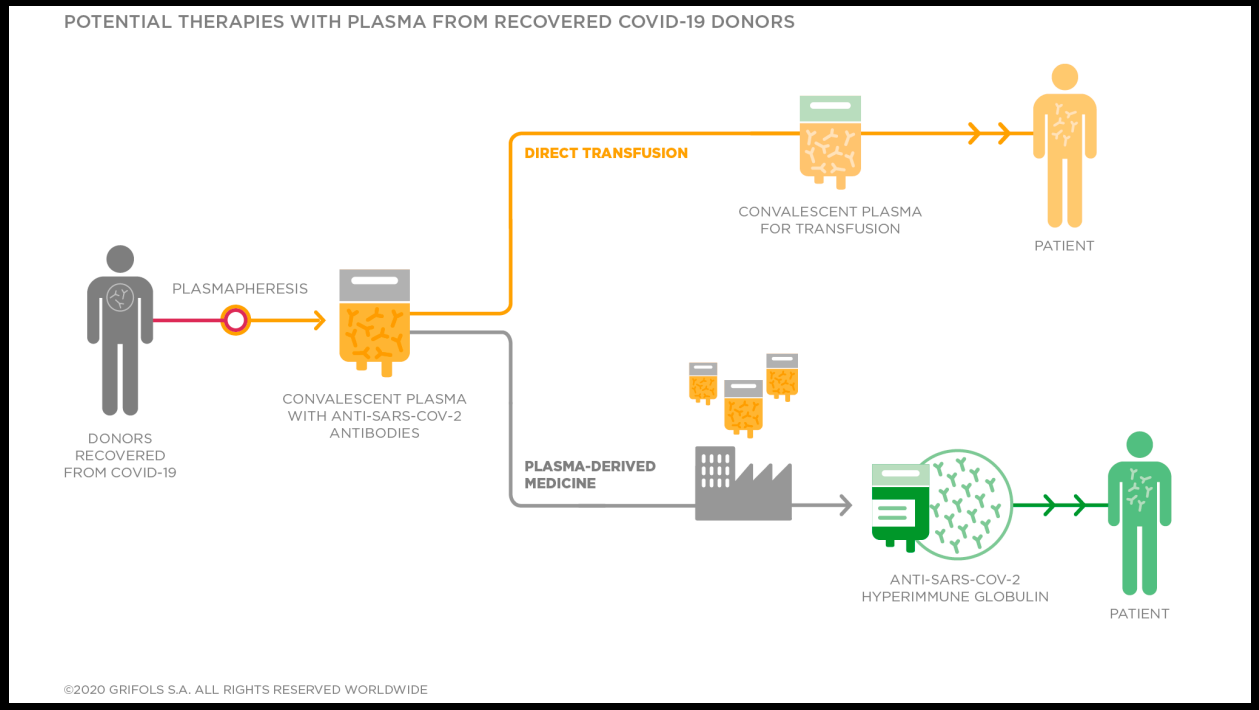
Back

September 29, 2020 at 4:01 PM EDT

REGENERON'S REGN-COV2 ANTIBODY COCKTAIL REDUCED VIRAL LEVELS AND IMPROVED SYMPTOMS IN NON-HOSPITALIZED COVID-19 PATIENTS

called seronegative group. The monoclonal cocktail showed little effect on people who already had antibodies against the virus. But it appeared to help the seronegative patients, powerfully reducing the amount of virus found in nasopharyngeal swabs and alleviating symptoms more quickly. “These are provocative results,” says Myron Cohen

An alternative to single antibody drugs



Serum transfer results

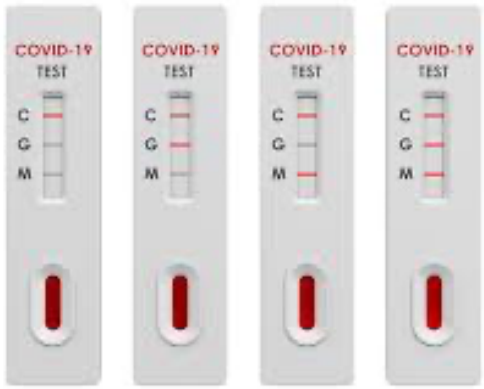
Clinical efficacy of convalescent plasma for treatment of COVID-19 infections: Results of a multicenter clinical study

Hassan Abolghasemi,[a] Peyman Eshghi,[b] Abdol Majid Cheraghali,[c,*] Abbas Ali Imani Fooladi,[a] Farzaneh Bolouki Moghaddam,[d] Sina Imanizadeh,[d] Matin Moeini Maleki,[d] Mohammad Ranjkesh,[d] Mohammad Rezapour,[d] Ali Bahramifar,[e] Behzad Einollahi,[f] Mohammad Javad Hosseini,[g] Nematollah Joneidi Jafari,[h] Mohamad Nikpouraghdam,[i] Nariman Sadri,[j] Mokhtar Tazik,[j] Shanaz Sali,[k] Shamsi Okati,[l] Elham Askari,[m] Payam Tabarsi,[m] Jafar Aslani,[n] Ehsan Sharifipour,[o] Mohammad Hossein Jarahzadeh,[p] Nastaran Khodakarim,[q] Mahmood Salesi,[n] Ramezan Jafari,[n] and Samira Shahverdi[r]

Abstract

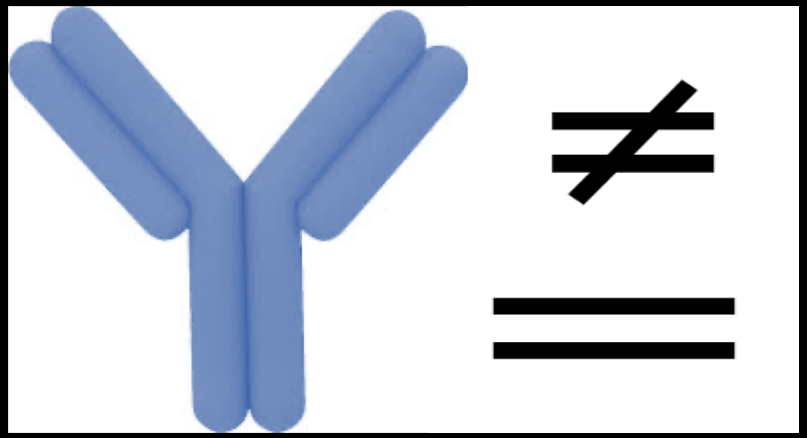
Go to:

Since Dec. 2019 the new coronavirus (SARS-CoV-2) has infected millions and claimed life of several hundred thousand worldwide. However, so far no approved vaccine or drug therapy is available for treatment of virus infection. Convalescent plasma has been considered a potential modality for COVID-19 infection. One hundred eighty-nine COVID-19 positive patients including 115 patients in plasma therapy group and 74 patients in control group, registered in the hospitals with confirmed COVID-19 infection, entered this multi-center clinical study. Comparison of outcomes including all-cause mortality, total hospitalization days and patients' need for intubation between the two patient groups shows that total of 98 (98.2 %) of patients who received convalescent plasma were discharged from hospital which is substantially higher compared to 56 (78.7 %) patients in control group. Length of hospitalization days was significantly lower (9.54 days) in convalescent plasma group compared with that of control group (12.88 days). Only 8 patients (7%) in convalescent plasma group required intubation while that was 20 % in control group. This clinical study provides strong evidence to support the efficacy of convalescent plasma therapy in COVID-19 patients and recommends this treatment for management of these patients. Clinical efficacy, immediate availability and potential cost effectiveness could be considered as main advantages of convalescent plasma therapy.



What does a SARS-CoV-2 antibody test result mean?

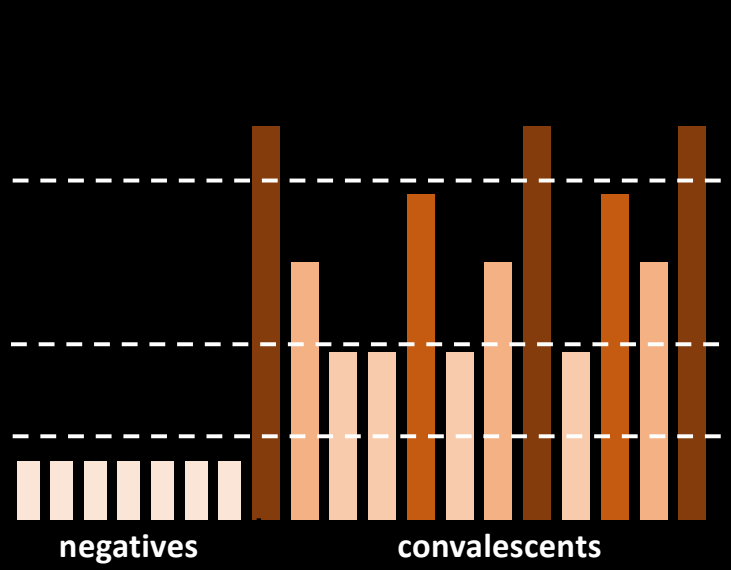
What does a positive antibody test mean?



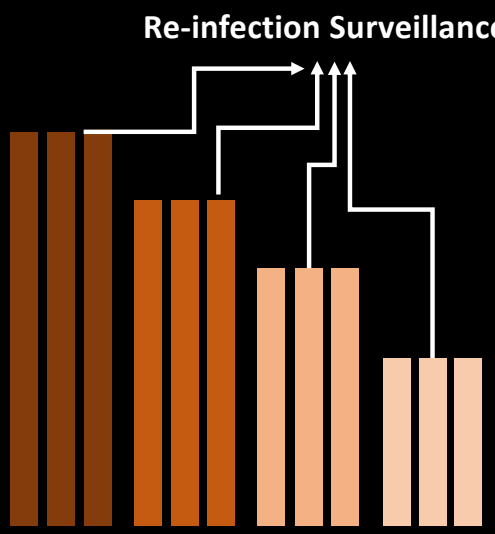
Immunity ≠ Exposure

Sero-Epidemiological studies are needed to establish a threshold of immunity.

Defining a protective titer…

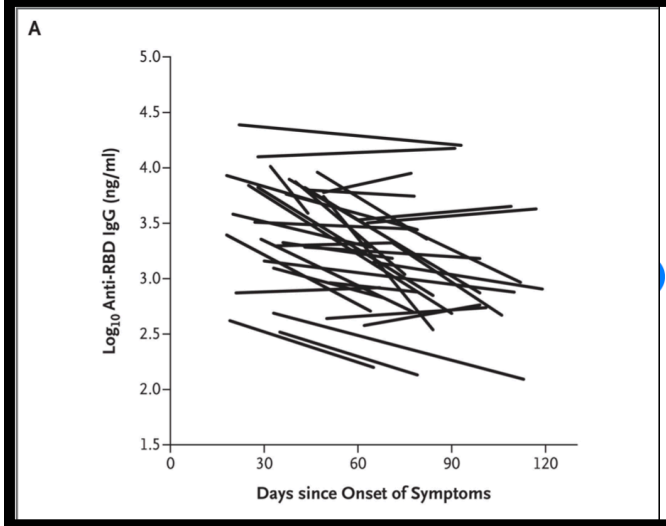


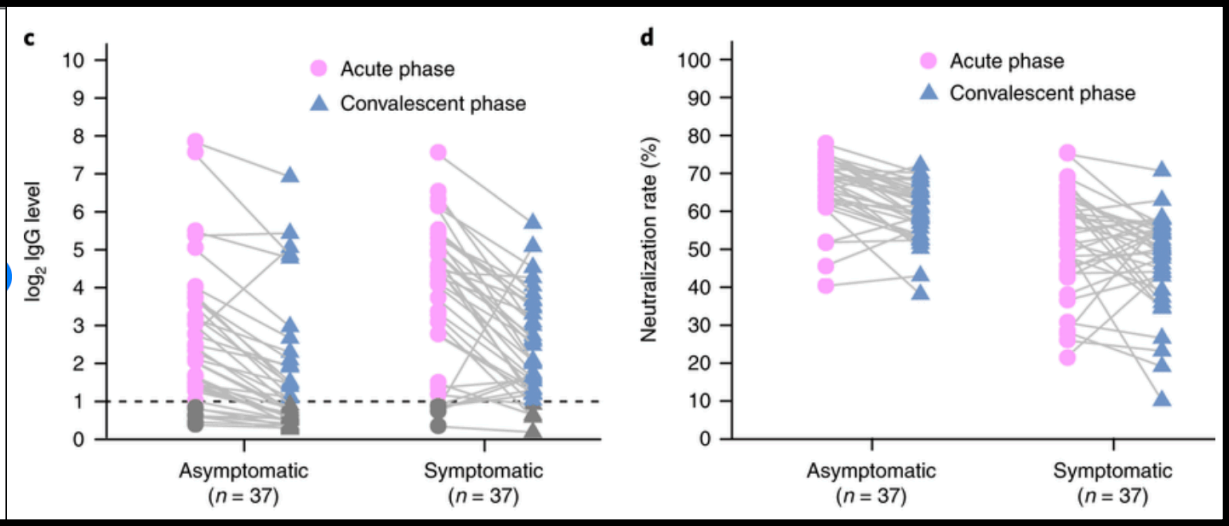
Re-infection?



What level of antibodies = IMMUNITY?

Evidence of waning immunity???






The NEW ENGLAND JOURNAL of MEDICINE

ESC Congress 2020 The Digital Experience

A correction has been published 1

CORRESPONDENCE

Rapid Decay of Anti–SARS-CoV-2 Antibodies in Persons with Mild Covid-19


Article · Publisher preview available

Clinical and immunological assessment of asymptomatic SARS-CoV-2 infections

nature research

August 2020 · Nature medicine 26(8)

DOI: 10.1038/s41591-020-0965-6

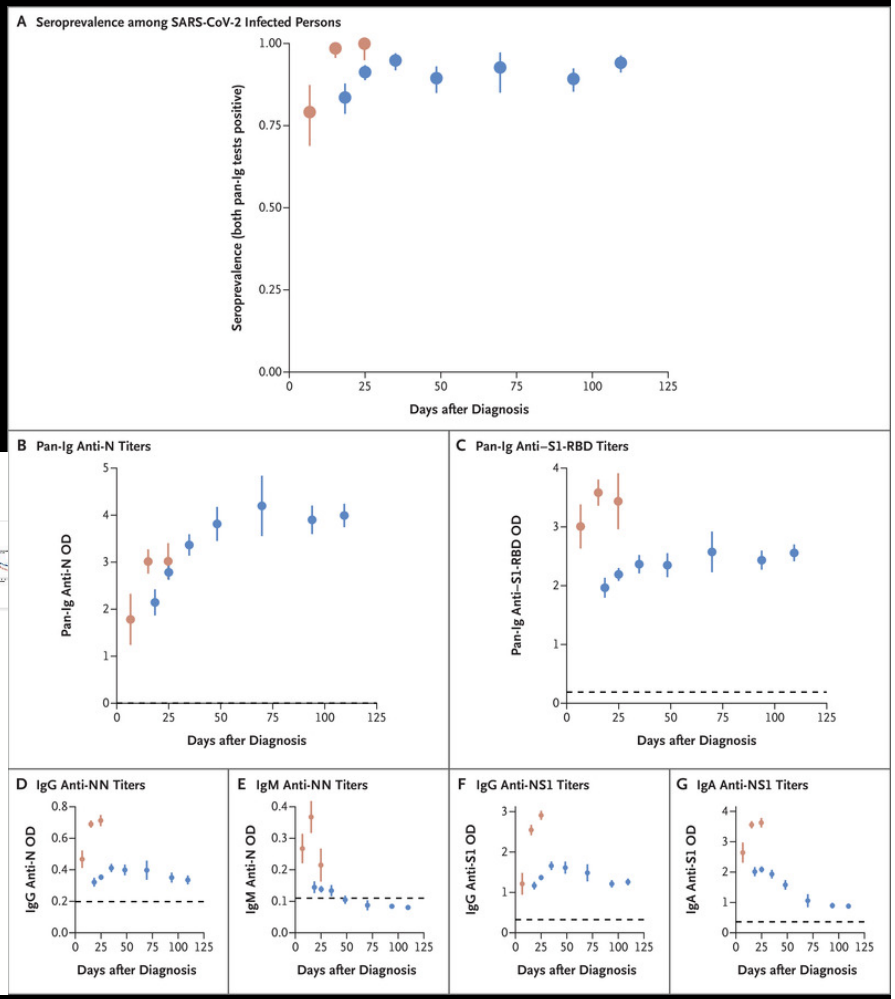
Stability of humoral immune responses over time

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Humoral Immune Response to SARS-CoV-2 in Iceland

Daniel F. Gudbjartsson, Ph.D., Gudmundur L. Norddahl, Ph.D., Pall Melsted, Ph.D., Kristbjorg Gunnarsdottir, M.Sc., Hilma Holm, M.D., Elias Eythorsson, M.D., Ph.D., Asgeir O. Arnthorsson, M.Sc., Dadi Helgason, M.D., Ph.D., Kristbjorg Bjarnadottir, Ph.D., Ragnar F. Ingvarsson, M.D., Brynja Thorsteinsdottir, B.Sc., Steinunn Kristjansdottir, B.Sc., Kolbrun Birgisdottir, B.Sc., Anna M. Kristinsdottir, M.Sc., Martin I. Sigurdsson, M.D., Ph.D., Gudny A. Arnadottir, M.Sc., Erna V. Ivarsdottir, M.Sc., Margret Andresdottir, M.Sc., Frosti Jonsson, M.Sc., Arna B. Agustsdottir, M.Sc., Jonas Berglund, Ph.D., Berglind Eiriksdottir, Run Fridriksdottir, M.Sc., Elisabet E. Gardarsdottir, Magnus Gottfredsson, M.D., Ph.D., Olafia S. Gretarsdottir, B.Sc., Steinunn Gudmundsdottir, M.Sc., Kjartan R. Gudmundsson, B.Sc., Thora R. Gunnarsdottir, B.Sc., Arnaldur Gylfason, M.Sc., Agnar Helgason, Ph.D., Brynjar O. Jensson, M.Sc., Aslaug Jonasdottir, M.Sc., Hakon Jonsson, Ph.D., Thordur Kristjansson, M.D., Ph.D., Karl G. Kristinsson, M.D., Ph.D., Droplaug N. Magnusdottir, M.Sc., Olafur T. Magnusson, Ph.D., Lovisa B. Olafsdottir, M.D., Solvi Rognvaldsson, B.Sc., Louise le Roux, M.Sc., Gudrun Sigmundsdottir, M.D., Asgeir Sigurdsson, B.Sc., Gardar Sveinbjornsson, M.Sc., Kristin E. Sveinsdottir, B.Sc., Maney Sveinsdottir, B.Sc., Emil A. Thorarensen, B.Sc., Bjarni Thorbjornsson, B.Sc., Marianna Thordardottir, Ph.D., Jona Saemundsdottir, B.Sc., S. Hjortur Kristjansson, M.D., Kamilla S. Josefsdottir, M.D., Gisli Masson, Ph.D., Gudmundur Georgsson, B.Sc., Mar Kristjansson, M.D., Alma Moller, M.D., Ph.D., Runolfur Palsson, M.D., Thorolfur Gudnason, M.D., Unnur Thorsteinsdottir, Ph.D., Ingileif Jonsdottir, Ph.D., Patrick Sulem, M.D., and Kari Stefansson, M.D., Ph.D.



First case of SARS-CoV-2 re-infection

NEWS HEALTH & MEDICINE

A man in Hong Kong is the first confirmed case of coronavirus reinfection

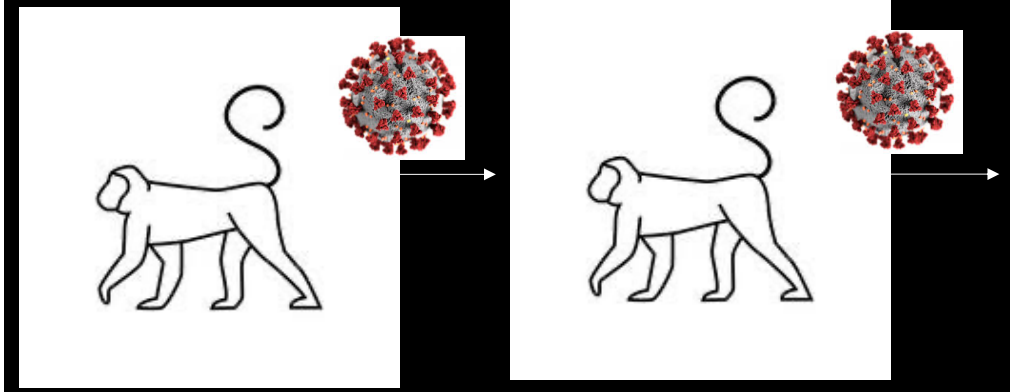
A 33-year-old got sick during his first round with the virus, but wasn't ill the second time

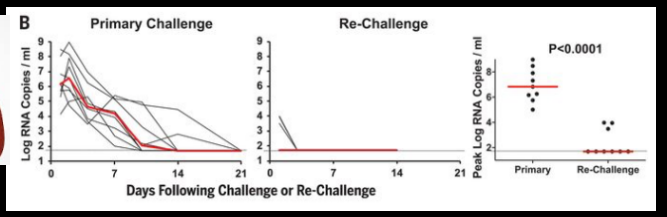
The first time the man was infected, he had a fever, cough, sore throat and headache for three days. He tested positive for the coronavirus on March 26 and was admitted to a hospital in Hong Kong three days later. At that point his symptoms had gone away. He was discharged on April 14 after he tested negative for the virus twice. But the man tested positive again more than four months later on August 15, when officials screened him upon returning to the Hong Kong airport from Spain. The second time, he never showed any indication of being sick — a sign that his immune system kicked in enough to protect him from the disease because he remained asymptomatic but not enough to prevent reinfection.

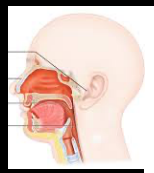
RESEARCH ARTICLE

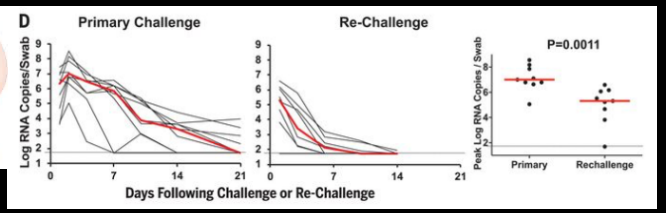
SARS-CoV-2 infection protects against rechallenge in rhesus macaques

Abishek Chandrashekar[1,*], Jinyan Liu[1,*], Amanda J. Martinot[1,2,*], Katherine McMahan[1,*], Noe B. Mercado[1,*], Lauren Peter[1,*], Lisa H. Tostanoski[1,*], Jingyou Yu[1,*], Zoltan Maliga[3], Michael Nekorchuk[4], Kathleen Busman-Sahay[4], Margaret Terry[4], Linda M. Wrijil[2], Sarah Ducat[2], David R. Martinez[5], Caroline Atyeo[3,6], Stephanie Fischinger[6], John S. Burke[6], Matthew D. Slein[6], Laurent Pessaint[7], Alex Van Ry[7], Jack Greenhouse[7], Tammy Taylor[7], Kelvin Blade[7], Anthony Cook[7], Brad Finneyfrock[7], Renita Brown[7], Elyse Teow[7], Jason Velasco[7], Roland Zahn[8], Frank Wegmann[8], Peter Abbink[1], Esther A. Bondzie[1], Gabriel Dagotto[1,3], Makda S. Gebre[1,3], Xuan He[1], Catherine Jacob-Dolan[1,3], Nicole Kordana[1], Zhenfeng Li[1], Michelle A. Lifton[1], Shant H. Mahrokhian[1], Lori F. Maxfield[1], Ramya Nityanandam[1], Joseph P. Nkolola[1], Aaron G. Schmidt[6,9], Andrew D. Miller[10], Ralph S. Baric[5], Galit Alter[6,9], Peter K. Sorger[3], Jacob D. Estes[4], Hanne Andersen[7], Mark G. Lewis[7], Dan H. Barouch[1,6,9,†]

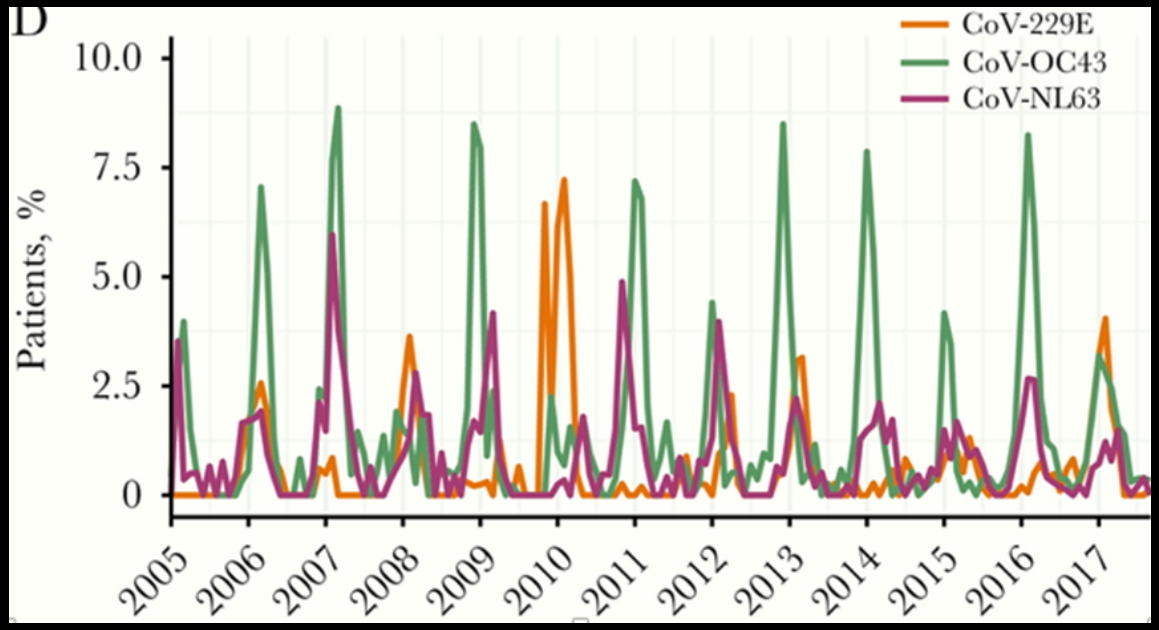




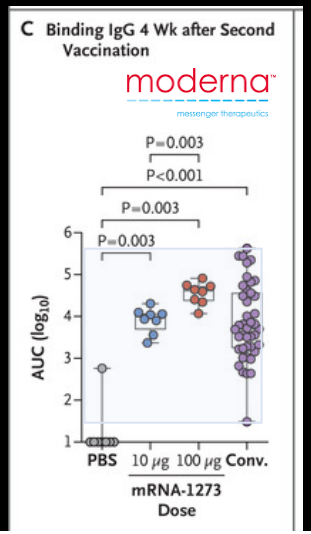




Does Coronavirus-specific immunity exist?



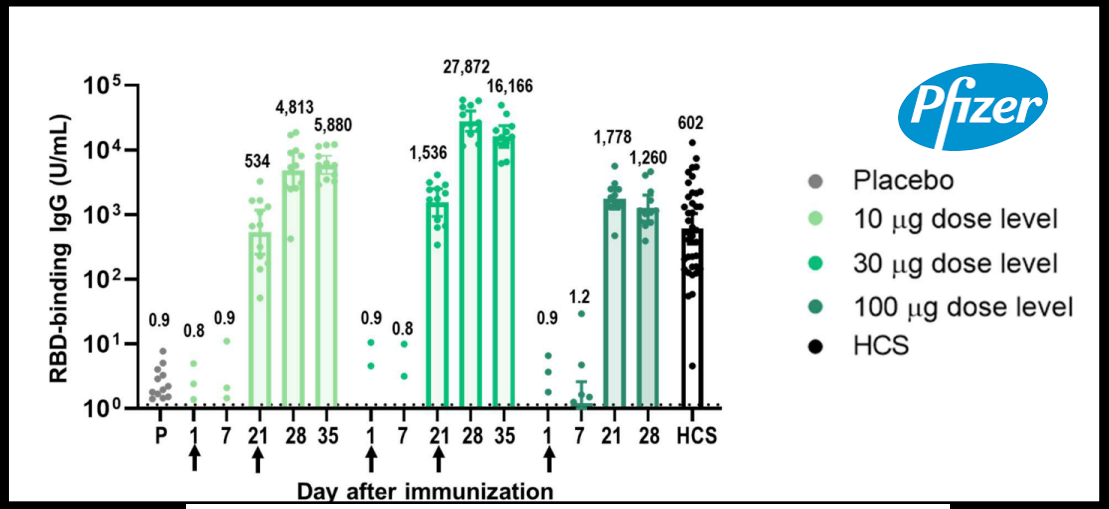
Vaccine Immunity is widely different than Natural Immunity



ORIGINAL ARTICLE

Evaluation of the mRNA-1273 Vaccine against SARS-CoV-2 in Nonhuman Primates

Kizzmekia S. Corbett, Ph.D., Barbara Flynn, M.S., Kathryn E. Foulds, Ph.D., Joseph R. Francica, Ph.D., Seyhan Boyoglu-Barnum, Ph.D., Anne P. Werner, B.S., Britta Flach, Ph.D., Sarah O'Connell, M.S., Kevin W. Bock, M.B., Mahnaz Minai, M.S., Bianca M. Nagata, M.S., Hanne Andersen, Ph.D., et al.



Positive Phase 1/2 Study Results of Pfizer COVID-19 mRNA Vaccine

Release time: 2020-07-14 Source: ACRO Read: 1862

Thank you!