

Supplementary Table S1. Representative contemporary H3N2 influenza A hemagglutinin (HA) and neuraminidase (NA) sequences and sequences for viruses used in the HI-assay. NCBI Genbank (www.ncbi.nlm.nih.gov/) or GISAID EpiFlu (www.gisaid.org) accession numbers and isolate name are provided.

HA Genbank Accession	NA Genbank Accession	Isolate Name	Originating lab
CY039087	CY035024	A/Brisbane/10/2007	
CY088483	CY088485	A/Fujian/411/2002	
JN638733	JN638732	A/Indiana/08/2011	
EPI_ISL_123206	EPI_ISL_123206	A/Indiana/12/2012	Indiana State Department of Health Laboratories, and CDC
AY531035	DQ487331	A/Moscow/10/99	
EPI_ISL_123207	EPI_ISL_123207	A/Ohio/13/2012	Ohio Department of Health Laboratories, and CDC
GQ293081	GQ293082	A/Perth/16/2009	
AF268128	AF268138	A/Swine/Colorado/23619/99	
KF739390	KF739392	A/Swine/Illinois/02907/2009	
CY107066	CY107068	A/swine/Illinois/A01201606/2011	
JX422557	JX422556	A/swine/Illinois/A01241066/2012	
JX422497	JX422496	A/swine/Illinois/A01241469/2012	
KC222299	KC222298	A/swine/Illinois/A01271623/2012	
KC822383	KC822382	A/swine/Illinois/A01445725/2013	
JX534982	JX534984	A/swine/Indiana/A00968373/2012	
JX092535	JX092572	A/swine/Indiana/A01202866/2011	
KC676308	KC676309	A/swine/Indiana/A01260185/2013	
CY099027	CY099029	A/swine/Iowa/01700/2007	
CY040516	CY040517	A/swine/Iowa/36243/2005	
AF251411	AF251412.3	A/Swine/Iowa/533/99	
JN652493	JN652524	A/swine/Iowa/A01049750/2011	
JX092307	JX092356	A/swine/Iowa/A01202613/2011	
JX092542	JX092579	A/swine/Iowa/A01202889/2011	
JX092555	JX092592	A/swine/Iowa/A01203121/2012	
JQ739697	JQ739709	A/swine/Iowa/A01203196/2012	

JQ739698	JQ739710	A/swine/Iowa/A01203197/2012
JX658776	JX658778	A/swine/Iowa/A01203751/2012
JX657018	JX657017	A/swine/Iowa/A01300195/2012
KC755694	KC755693	A/swine/Iowa/A01432500/2013
GU135941	GU135943	A/swine/Iowa/H03LDH5/2003
JX163265	JX163276	A/swine/Michigan/A01203498/2012
JX442056	JX442058	A/swine/Michigan/A01259000/2012
KC839567	KC839569	A/swine/Michigan/A01259034/2012
KC534987	KC534986	A/swine/Michigan/A01432375/2013
CY099247	CY099249	A/swine/Minnesota/00484/2005
CY099061	CY099063	A/swine/Minnesota/00709/2005
CY099035	CY099037	A/swine/Minnesota/01146/2006
CY099103	CY099105	A/swine/Minnesota/02782/2009
HQ315643	FJ519965	A/swine/Minnesota/1300/2007
JX401343	JX401345	A/swine/Minnesota/14/2012
JX853749	JX853751	A/swine/Minnesota/18/2012
FJ519976	FJ519966	A/swine/Minnesota/5947/2007
JX422257	JX422256	A/swine/Minnesota/A01125993/2012
KC576834	KC576836	A/swine/Minnesota/A01280462/2013
KC589443	KC589445	A/swine/Minnesota/A01280592/2013
JX657030	JX657029	A/swine/Minnesota/A01300213/2012
JX422521	JX422520	A/swine/Minnesota/A01327922/2012
KC715696	KC715695	A/swine/Minnesota/A01432433/2013
KC841830	KC841829	A/swine/Minnesota/A01432544/2013
AF251403	AF251404	A/Swine/Nebraska/209/98
JX422575	JX422574	A/swine/Nebraska/A01241171/2012
KC222305	KC222304	A/swine/Nebraska/A01271549/2012
CY040538	CY040539	A/swine/North Carolina/38715/2005
KC841842	KC841841	A/swine/North Carolina/A01432566/2013
JN940422	JN940424	A/swine/NY/A01104005/2011

AF268123	AF268136	A/Swine/Oklahoma/18717/99	
JF263535	JX657759	A/swine/Pennsylvania/A01076777/2010	
KC526198	KC526200	A/swine/South Dakota/A01280095/2013	
CY095675	CY095677	A/swine/Texas/4199-2/1998	
JN652507	JN652541	A/swine/Texas/A01049914/2011	
AF268126	AF268137	A/Swine/Wisconsin/14094/99	
KC562197	KC562196	A/swine/Wyoming/A01444562/2013	
CY039079	AJ291403	A/Sydney/5/1997	
JN706700	JN706702	A/turkey/Ontario/FAV-10/2011	
JN683629	JN683631	A/turkey/Ontario/FAV-9/2011	
JX905419	JX905418	A/Utah/10/2012	
KC306165	EPI_ISL_101506	A/Victoria/361/2011	WHO Collaborating Centre for Reference and Research on Influenza, AUS
CY034116	CY034118	A/Wisconsin/67/2005	
AY661190	U51246	A/Wuhan/359/95	

Supplementary Table S2. All U.S. swine IAV H3N2 HA sequences from 1977 to present downloaded from the Influenza Virus Resource on July 2, 2013.

HA Genbank Accession	Isolate Name	Originating lab
M73774	A/swine/Colorado/1/1977	
AF153232	A/Swine/NorthCarolina/35922/98	
AF153233	A/swine/Texas/4199-2/1998	
AF153234	A/Swine/Minnesota/9088-2/98	
AF153235	A/Swine/Iowa/8548-1/98	
AF251403	A/Swine/Nebraska/209/98	
AF251411	A/Swine/Iowa/533/99	
AF251419	A/Swine/Iowa/569/99	
AF268123	A/Swine/Oklahoma/18717/99	
AF268124	A/Swine/Illinois/21587/99	
AF268125	A/Swine/Oklahoma/18089/99	
AF268126	A/Swine/Wisconsin/14094/99	
AF268127	A/Swine/NorthCarolina/16497/99	
AF268128	A/Swine/Colorado/23619/99	
CY009308	A/swine/Wisconsin/194/1980	
CY009300	A/swine/Colorado/1/1977	
AF251427	A/Swine/Minnesota/593/99	
EF551053	A/swine/NorthCarolina/2003	
EU422987	A/swine/Iowa/H02AS8/2002	
EU422988	A/swine/Iowa/H03HO7/2003	
CY035416	A/swine/Minnesota/SG234/2005	
CY035419	A/swine/Minnesota/SG235/2007	
CY035422	A/swine/Minnesota/SG236/2007	
CY035426	A/swine/Minnesota/SG237/2007	
CY035442	A/swine/Minnesota/SG242/2006	
FJ410140	A/swine/Minnesota/1145/2007	
FJ519971	A/swine/Minnesota/65767/2006	
FJ519972	A/swine/Minnesota/66853/2006	
FJ519973	A/swine/Minnesota/66960/2006	
FJ519974	A/swine/Minnesota/578/2007	
FJ519975	A/swine/Minnesota/761/2007	
FJ519976	A/swine/Minnesota/5947/2007	
FJ519977	A/swine/Minnesota/7931/2007	
CY040459	A/swine/Arkansas/63607-20/2008	
CY040462	A/swine/Illinois/63607-18/2008	
CY040463	A/swine/Illinois/63607-2/2008	
CY040464	A/swine/Illinois/63607-22/2008	
CY040465	A/swine/Illinois/63607-36/2008	
CY040469	A/swine/Iowa/63607-13/2008	
CY040470	A/swine/Iowa/63607-19/2008	
CY040484	A/swine/Minnesota/63607-29/2008	
CY040498	A/swine/NorthCarolina/225-7/2008	
CY040506	A/swine/NorthCarolina/63607-38/2008	

CY040511	A/swine/Oklahoma/225-14/2008
CY040516	A/swine/Iowa/36243/2005
CY040518	A/swine/Illinois/34642/2005
CY040538	A/swine/NorthCarolina/38715/2005
CY040581	A/swine/Iowa/36241/2005
CY040582	A/swine/Minnesota/18815/2005
CY040583	A/swine/Minnesota/21057/2005
CY040584	A/swine/Minnesota/24877/2005
CY040585	A/swine/Missouri/36702/2005
CY045551	A/swine/Oklahoma/001142/2009
CY045559	A/swine/Kansas/015252/2009
CY045567	A/swine/Oklahoma/008722/2007
CY045575	A/swine/Oklahoma/011506/2007
GU135941	A/swine/Iowa/H03LDH5/2003
GU135918	A/swine/Iowa/H03HB4/2003
GU135891	A/swine/Iowa/H03BF5/2003
GU289666	A/swine/Wisconsin/R7c/2001
GU721165	A/swine/Illinois/02945/2010
GU565035	A/swine/Illinois/02940/2010
GU817053	A/swine/Minnesota/02948/2009
GU817057	A/swine/Minnesota/02952/2009
GU968905	A/swine/Minnesota/02981/2010
HM025943	A/swine/Missouri/02980/2010
HM217202	A/swine/Minnesota/03008/2010
HM570052	A/swine/Iowa/03017/2010
HM778115	A/swine/Illinois/03040/2010
HM778116	A/swine/Illinois/03041/2010
HQ315643	A/swine/Minnesota/1300/2007
HQ734186	A/swine/Illinois/53612-1/2009
HQ734189	A/swine/Illinois/53612-2/2009
HQ734192	A/swine/Illinois/53612-3/2009
HQ734195	A/swine/Illinois/53612-4/2009
HQ734198	A/swine/Illinois/53612-5/2009
HQ734201	A/swine/Illinois/53612-6/2010
HQ734204	A/swine/Illinois/53612-7/2010
JF263535	A/swine/Pennsylvania/62170-1/2010
JF263536	A/swine/Pennsylvania/62170-3/2010
JF316643	A/swine/Pennsylvania/057108-1/2010
JF312071	A/swine/Iowa/A01057188/2010
JF312072	A/swine/Illinois/A01057087/2010
JF312073	A/swine/Illinois/A01057088/2010
CY086920	A/swine/Minnesota/239105/2009
JF312064	A/swine/Pennsylvania/62170-2/2010
JF312065	A/swine/Pennsylvania/62170-4/2010
JF812274	A/swine/Iowa/A01049031/2010
JF812275	A/swine/Iowa/A01049032/2010
JF812276	A/swine/Iowa/A01049034/2010
JF812277	A/swine/Iowa/A01049035/2010

JF812289	A/swine/Indiana/A01049091/2010
JF812293	A/swine/Iowa/A01049112/2010
JF833334	A/swine/Iowa/A01049113/2010
JF833336	A/swine/Indiana/A01049124/2010
JF833340	A/swine/Iowa/A01049160/2010
JF833345	A/swine/Iowa/A01049185/2010
JN162046	A/swine/Nebraska/A01049235/2010
JN162051	A/swine/Iowa/A01049254/2010
JN162052	A/swine/Pennsylvania/A01049256/2010
JN162053	A/swine/Iowa/A01049317/2010
JN162054	A/swine/Minnesota/A01049346/2010
JN162059	A/swine/NorthCarolina/A01049436/2011
CY095675	A/swine/Texas/4199-2/1998
JN409391	A/swine/Kansas/10-91088/2010
JN409399	A/swine/Kansas/11-101926/2011
JN409407	A/swine/Kansas/11-104465/2011
JN409415	A/swine/Kansas/11-104467/2011
JN409423	A/swine/Kansas/11-107824/2011
JN409431	A/swine/Kansas/11-109700/2011
JN409439	A/swine/Kansas/11-110529/2011
CY099027	A/swine/Iowa/01700/2007
CY099035	A/swine/Minnesota/01146/2006
CY099061	A/swine/Minnesota/00709/2005
CY099103	A/swine/Minnesota/02782/2009
CY099111	A/swine/Minnesota/01862/2007
CY099143	A/swine/Minnesota/00611/2005
CY099215	A/swine/Minnesota/001444/2007
CY099231	A/swine/Minnesota/001332/2006
CY099247	A/swine/Minnesota/00484/2005
JN652491	A/swine/Indiana/A01049744/2011
JN652492	A/swine/Indiana/A01049745/2011
JN652493	A/swine/Iowa/A01049750/2011
JN652507	A/swine/Texas/A01049914/2011
JN652508	A/swine/Texas/A01049915/2011
JN652510	A/swine/Minnesota/A01049936/2011
JN652511	A/swine/Nebraska/A01049937/2011
JN652407	A/swine/Texas/A01049555/2011
JN652408	A/swine/Texas/A01049556/2011
JN652415	A/swine/Indiana/A01049653/2011
JN940422	A/swine/NY/A01104005/2011
JQ350538	A/swine/Iowa/A01202709/2011
JQ350530	A/swine/Iowa/A01202659/2011
JQ350522	A/swine/Iowa/A01202640/2011
CY107015	A/swine/NorthCarolina/A01076178/2009
CY107020	A/swine/Indiana/A01076191/2010
CY107028	A/swine/Minnesota/A01076196/2010
CY107035	A/swine/NorthCarolina/A01076199/2010
CY107043	A/swine/NorthCarolina/A01076204/2010

CY107051	A/swine/NorthCarolina/A01076212/2010
CY107058	A/swine/Minnesota/A01076218/2010
CY107066	A/swine/Illinois/A01201606/2011
JQ398784	A/swine/NorthCarolina/A01202766/2011
JQ398788	A/swine/NorthCarolina/A01048779/2011
JQ661488	A/swine/NorthCarolina/A01202768/2011
JQ689163	A/swine/Indiana/A01049349/2010
JQ689155	A/swine/Indiana/A00968322/2010
JQ689153	A/swine/Indiana/A00968321/2010
JQ689165	A/swine/Illinois/A01076719/2010
JQ689160	A/swine/Illinois/A01047528/2010
JQ689157	A/swine/Illinois/A01047183/2010
JQ689148	A/swine/Iowa/A01202088/2011
JQ689140	A/swine/Nebraska/A01104010/2011
JQ689132	A/swine/Iowa/A01049036/2010
JQ689124	A/swine/Iowa/A01049033/2010
JQ689116	A/swine/Missouri/A01047969/2010
JQ689108	A/swine/Missouri/A01047968/2010
JQ689100	A/swine/Illinois/A01047529/2010
JQ689092	A/swine/Minnesota/A01047396/2011
JQ689084	A/swine/Illinois/A01047188/2010
JQ738179	A/swine/Illinois/A00857304b/2012
JQ738171	A/swine/Illinois/A00857304a/2012
JQ738163	A/swine/Illinois/A00857138b/2011
JQ738155	A/swine/Illinois/A00857138a/2011
JQ738147	A/swine/Illinois/A00857300/2011
JQ738139	A/swine/Pennsylvania/a01076503/2010
JQ738131	A/swine/Pennsylvania/a01076502/2010
JQ739697	A/swine/Iowa/A01203196/2012
JQ739698	A/swine/Iowa/A01203197/2012
JQ756375	A/swine/Illinois/A01076865/2010
JQ756376	A/swine/Minnesota/A01134337/2010
JQ756377	A/swine/Missouri/A01240017/2011
JQ756378	A/swine/Minnesota/A01240088/2011
JQ756379	A/swine/Minnesota/A01240095/2011
JQ756380	A/swine/Minnesota/A01240127/2011
JQ783061	A/swine/Minnesota/A00907734/2011
JQ783062	A/swine/Iowa/A01047906/2010
JQ783063	A/swine/Pennsylvania/A01047912/2010
JQ783064	A/swine/NorthCarolina/A01047914/2011
JQ783065	A/swine/NorthCarolina/A01076214/2010
JQ783066	A/swine/Iowa/A01076311/2010
JQ783067	A/swine/Iowa/A01076630/2010
JQ783068	A/swine/Iowa/A01076632/2010
JQ783069	A/swine/Minnesota/A01076701/2010
JQ783070	A/swine/Illinois/A01076859/2010
JQ783071	A/swine/Minnesota/A01116195/2011
JQ783072	A/swine/Minnesota/A01116200/2011

JQ783073	A/swine/Nebraska/A01116980/2011
JQ783074	A/swine/Illinois/A01201076/2011
JQ783075	A/swine/Minnesota/A01201437/2011
JQ783076	A/swine/Pennsylvania/A01201666/2011
JQ783077	A/swine/Illinois/A01201770/2011
JQ783078	A/swine/Minnesota/A01201894/2011
JQ791012	A/swine/Minnesota/A01076999/2010
JQ791004	A/swine/Illinois/A01047014/2010
JQ790996	A/swine/Illinois/A01047009/2010
CY116624	A/swine/Minnesota/A01240557/2011
JQ922312	A/swine/Illinois/A01076708/2010
JQ922327	A/swine/Missouri/A01240016/2011
CY041847	A/swine/NorthCarolina/R08-001877-D08-013371/2008
JX042530	A/swine/Minnesota/A01076193/2010
JX042538	A/swine/Iowa/A01076309/2010
JX042540	A/swine/Iowa/A01076507/2010
JX042541	A/swine/Iowa/A01076508/2010
JX042542	A/swine/Minnesota/A01076531/2010
JX042543	A/swine/Illinois/A01076709/2010
JX042544	A/swine/Illinois/A01076724/2010
JX042545	A/swine/Illinois/A01076730/2010
JX042546	A/swine/Illinois/A01076735/2010
JX042547	A/swine/Illinois/A01076768/2010
JX042552	A/swine/Illinois/A01201633/2011
JX080531	A/swine/Iowa/A01203304/2012
JX080538	A/swine/Indiana/A01203372/2012
JX080548	A/swine/Virginia/A01203436/2012
JX080549	A/swine/Virginia/A01203437/2012
JX080553	A/swine/Iowa/A01203459/2012
JX080554	A/swine/Iowa/A01203463/2012
JX080557	A/swine/Iowa/A01243311/2012
JX080619	A/swine/Iowa/A01049119/2010
JX092272	A/swine/Iowa/A01202089/2011
JX092297	A/swine/Iowa/A01202529/2011
JX092298	A/swine/Iowa/A01202530/2011
JX092300	A/swine/Iowa/A01202573/2011
JX092307	A/swine/Iowa/A01202613/2011
JX092308	A/swine/Iowa/A01202614/2011
JX092311	A/swine/Indiana/A01202621/2011
JX092316	A/swine/Iowa/A01202639/2011
JX092415	A/swine/Michigan/A01202655/2011
JX092416	A/swine/Iowa/A01202657/2011
JX092417	A/swine/Iowa/A01202658/2011
JX092444	A/swine/Illinois/A01202825/2011
JX092535	A/swine/Indiana/A01202866/2011
JX092536	A/swine/Indiana/A01202867/2011
JX092537	A/swine/Iowa/A01202878/2011
JX092538	A/swine/Iowa/A01202879/2011

JX092542	A/swine/Iowa/A01202889/2011
JX092544	A/swine/Iowa/A01202905/2011
JX092545	A/swine/Iowa/A01202906/2011
JX092549	A/swine/Illinois/A01202978/2011
JX092552	A/swine/Iowa/A01203104/2011
JX092555	A/swine/Iowa/A01203121/2012
JX092561	A/swine/Ohio/A01203186/2012
JX092569	A/swine/Iowa/A01203248/2012
JX092570	A/swine/NorthCarolina/A01203272/2012
JX090162	A/swine/Illinois/A01201763/2011
JX099413	A/swine/Illinois/A00857318a/2012
CY121886	A/swine/Ohio/1/2012
CY122052	A/swine/Minnesota/2/2012
CY122318	A/swine/SouthDakota/3/2012
CY122321	A/swine/Minnesota/4/2012
CY122327	A/swine/Ohio/6/2012
CY114592	A/swine/Minnesota/A01201424/2010
CY114798	A/swine/Illinois/A01201077/2011
CY114840	A/swine/Illinois/A01201606/2011
CY114846	A/swine/Illinois/A01201629/2011
CY114849	A/swine/Illinois/A01201631/2011
CY114857	A/swine/Minnesota/A01201895/2011
CY114874	A/swine/Minnesota/A00907733/2011
CY114884	A/swine/Illinois/A01116190/2011
CY114909	A/swine/Minnesota/A01116381/2011
CY114952	A/swine/Nebraska/A01116984/2011
CY124830	A/swine/Ohio/9/2012
CY124833	A/swine/Ohio/7/2012
CY124839	A/swine/Pennsylvania/A01076501/2010
JX163262	A/swine/Iowa/A01203482/2012
JX163264	A/swine/Iowa/A01203492/2012
JX163265	A/swine/Michigan/A01203498/2012
JX163266	A/swine/Iowa/A01203503/2012
JX163268	A/swine/Indiana/A01203509/2012
JX163269	A/swine/Minnesota/A01203517/2012
JX163270	A/swine/Indiana/A01203521/2012
JX163271	A/swine/Indiana/A01203522/2012
JX273046	A/swine/Nebraska/A01300032/2012
JX267175	A/swine/Iowa/A01203571/2012
JX280444	A/swine/Minnesota/A01125995/2012
JX280450	A/swine/Texas/A01104013/2012
JX401343	A/swine/Minnesota/14/2012
JX442056	A/swine/Michigan/A01259000/2012
JX444786	A/swine/Iowa/A01203612/2012
JX444787	A/swine/Ohio/A01203624/2012
JX463278	A/swine/Indiana/A01327236/2010
JX463284	A/swine/Indiana/A01327235/2010
JX463287	A/swine/Indiana/A01327234/2010

JX494412	A/swine/Indiana/A00968380/2012
JX543519	A/swine/Illinois/A01203672/2012
JX534998	A/swine/Indiana/A00968379/2012
JX534990	A/swine/Indiana/A00968376/2012
JX534982	A/swine/Indiana/A00968373/2012
JX534974	A/swine/Indiana/A00968370/2012
JX534969	A/swine/Ohio/12TOSU293/2012
JX534961	A/swine/Ohio/12TOSU268/2012
CY116566	A/swine/Wisconsin/H02AS8/2002
JX549145	A/swine/Indiana/A00968386/2012
JX549137	A/swine/Indiana/A01104030/2012
JX549130	A/swine/Indiana/A01104029/2012
JX549123	A/swine/Indiana/A01104023/2012
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 CY088483 A/Fujian/411/2002
 EPI_ISL_101506 A/Victoria/361/2011
 GQ293081 A/Perth/16/2009
 CY034116 A/Wisconsin/67/2005
 CY039087 A/Brisbane/10/2007
 AY661190 A/Wuhan/359/95
 AY531035 A/Moscow/10/99
 CY039079 A/Sydney/5/1997
 JN683629 A/turkey/Ontario/FAV-9/2011
 JN706700 A/turkey/Ontario/FAV-10/2011
 JN638733 A/Indiana/08/2011

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JX905419	A/Utah/10/2012	
JN940422	A/swine/NY/A01104005/2011	
EPI_ISL_123207	A/Ohio/13/2012	Ohio Department of Health Laboratories, and CDC
EPI_ISL_123206	A/Indiana/12/2012	Indiana State Department of Health Laboratories, and CDC
KF739390	A/Swine/Illinois/02907/2009	

Table S3. Hemagglutination inhibition (HI) titers utilized in the antigenic cartography analyses.*

Table with 57 columns and 57 rows. Each column and row is labeled with a specific H1N1vA strain (e.g., A_H1N1vA_MUHAN/0359/1995). The cells contain HI titers, often in bold text, representing the results of hemagglutination inhibition assays for each pair of strains.

*Replicate tests reported as geometric mean titers.

Position	Human	Swine	Equine
145	N145K	N145K S145N/R	N/D
155	T155Y Y155H	H155Y Y155H	N/D
156	K156E E156K K156Q Q156K Q156H	N/S156K N/S156H N156K	N/D
158	G158E E158K	N/D158G	N/D
159	S159Y	Y159H Y159N	N159S
189	Q189K K189R	K189R K189R/S K189E	K189Q/E/D/N
193	N193S D193N	N/D	N/D

Table S4. Amino acid positions and substitutions associated with antigenic evolution in three mammalian host species (compiled from references 26, 42, 45 and this study). N/D = not detected.

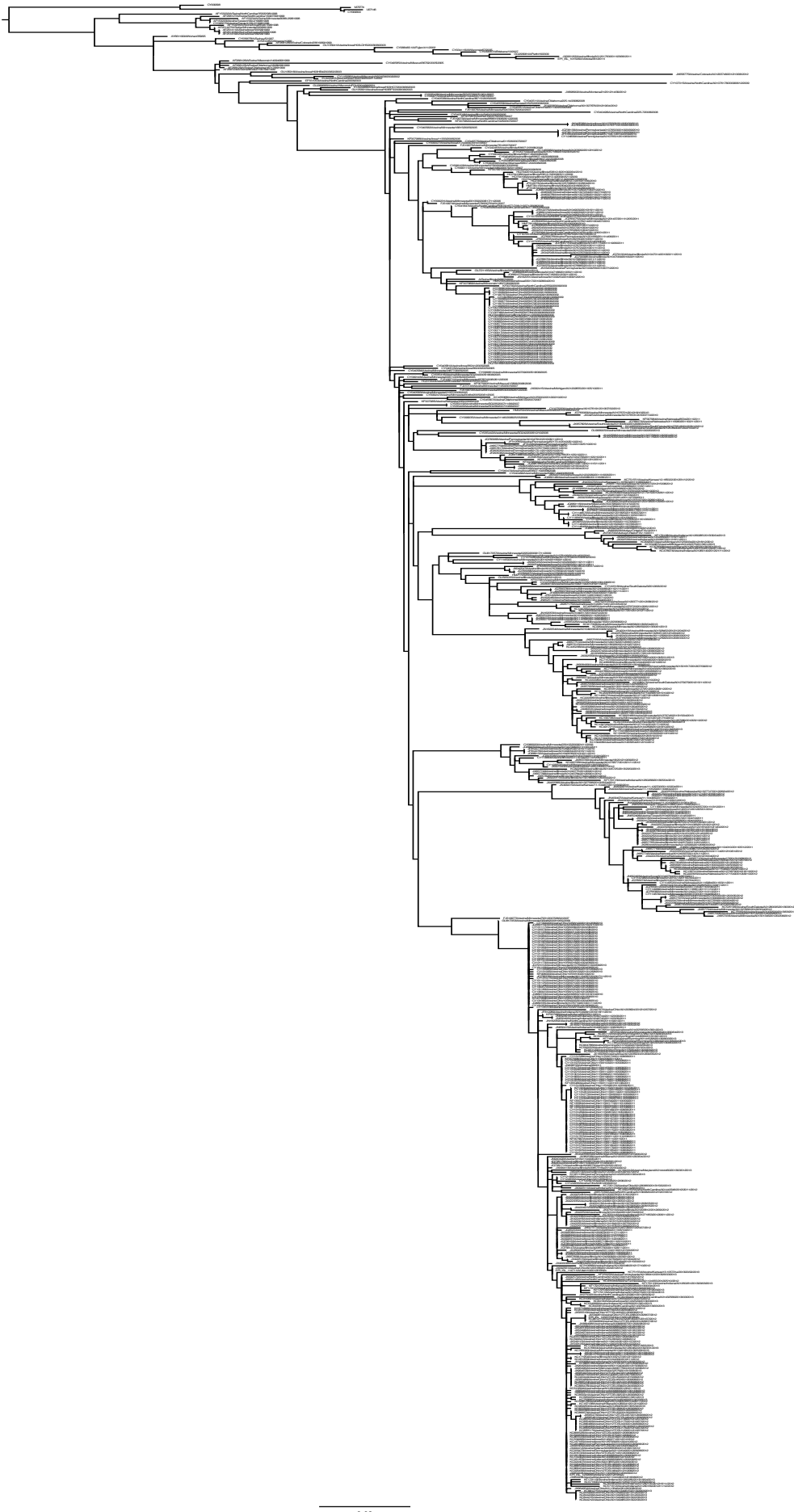


Figure S1. Phylogenetic relationships of hemagglutinin (HA) sequences from 672 swine influenza A virus isolates collected in the United States. Tree was constructed using the maximum likelihood method and a GTR+ Γ substitution model implemented in RAxML v.7.4.2. Statistical support was estimated from 1,000 resamplings of the sequence data; data available upon request. The tree is midpoint rooted for clarity; scale bar indicates nucleotide substitutions per site.



Figure S2. Amino acid sequence alignment with viruses grouped and color-coded based on antigenic cluster and marked with cluster-defining amino acid substitutions relative to the Cluster I H3 prototype.