Index

Figures are indicated by the letter f following the page number; tables are indicated by the letter t following the page number

A

AAEP see American Association of Equine Practitioners
ACIA see antigen capture immunoassays
acute-phase proteins (APP), 137, 139
Ad5 see adenovirus serotype 5
adenovirus serotype 5 (Ad5), 494–495
adjuvants, 392–393, 406, 488
agar gel immunodiffusion (AGID) assay
global nature of avian influenza, 177–178
vaccination, 413–415
virus detection, 35, 38–39
AIAO see all-in all-out
Ailuropoda melanoleuca, 566
Ailurus fulgens, 566
AIV see avian influenza virus
Aix sponsa, 163
Alligator sinensis, 581
all-in all-out (AIAO) farm management, 446
Alopecoenegyptiacus, 251
alpha-2,3/alpha-2,6 sialic acid
immunity, 140
influenza A virus, 7
mammalian experimental models, 596, 597f, 602–603
amantadine, 110
American Association of Equine Practitioners (AAEP), 524
Anas spp.
epidemiology in man-made systems, 305
goose/Guangdong-lineage H5 HPAIV, 225–226
H7N3 HPAIV outbreak in Mexico (2012–2014), 259
H7N7 HPAIV in the UK (2008), 256
pathobiology of avian influenza in domestic ducks, 337, 352
wild birds and AIV ecology, 153, 155, 157, 162–163
animal health systems, 67–68
Anser spp., 156, 158, 305
antigen capture immunoassays (ACIA), 31, 36
antigenic drift and shift
global evolution of IAVs in swine, 466–467
goose/Guangdong-lineage H5 HPAIV, 207, 208, 219
influenza A virus, 18–21
antigenic mapping, 136, 142–146, 208
antigenic matching of vaccine seed strain, 405, 488
antigen-presenting cells (APC), 139–140
antimicrobial resistance, 110, 208
APC see antigen-presenting cells
APMV-8 see avian paramyxovirus type 8
APP see acute-phase proteins
Arctocephalus australis, 570
Ardea cinerea, 212
Ardeola bacchus, 214
Arenaria interpres, 157
avian influenza virus (AIV)
antigenic drift and shift, 19–21
bat origin influenza, 10
canine influenza virus, 553
clinical disease in poultry, 14–18
control strategies, 363–377
diagnostics and surveillance methods, 31–37
ecology in wild birds, 8–10
economics of animal influenza, 45–51, 53–54
epidemiology in man-made systems, 10–13, 302–336
equine influenza virus, 505–507
global nature of avian influenza, 177–201
goose/Guangdong-lineage H5 HPAIV, 202–247
HPAIV outbreaks since 2008, 248–270
immunity, 135–152
mammalian experimental models, 594, 598–605, 607–608
propagation, 6
public health, 92–111, 116–118
sporadic IAV infections in mammals, 557–572
trade and food safety, 76–87
vaccines and vaccination for AI in poultry, 378–434
virus life cycle, 7–8
wild birds, 153–176
see also high-pathogenicity avian influenza viruses; individual virus strains; low-pathogenicity avian influenza viruses
avian paramyxovirus type 8 (APMV-8), 396
Aythya spp., 163

B

Balaenoptera acutorostrata, 576
bats
environmental reservoirs, 156–157
influenza A virus, 10
sporadic IAV infections in mammals, 577–581, 580f
biosecurity
control strategies, 368–369
economics of animal influenza, 65–66

biosecurity (continued)
epidemiology in man-made systems, 304, 310, 318, 323, 325
goose/Guangdong-lineage H5 HPAIV, 226, 231–232, 235
ostich H5N2 HPAIV infections in South Africa (2004–2011), 254
public health, 104, 119
swine influenza virus, 456
\textit{Bos taurus}, 564, 574
\textit{Branta canadensis}, 156
\textit{Cairina moschata}, 305, 337, 350–352
\textit{Calidris canutus}, 156
\textit{Caiman latirostris}, 581
\textit{Closera niloticus}, 581
\textit{Crotogale owstoni}, 214, 562
candidate vaccine viruses (CVV), 118
canine influenza virus (CV), 549–556
clinical disease, 551–552, 551f, 552, 553f
emergence and spread, 549–550, 552
epidemiology in man-made systems, 308
epidemiology, spread, and control, 551, 552–553
genetics, 14
H3N2 canine influenza virus, 552–553
H3N8 canine influenza virus, 275, 308, 549–552
infection of other hosts and re-assortments, 552
LPAIVs in live poultry markets, 275
mammalian experimental models, 604
phylogenetic tree, 550f
sporadic IAV infections in mammals, 565, 573
vaccination, 552, 553
captive birds
epidemiology in man-made systems, 310
global nature of avian influenza, 182–183
\textit{Crotogale owstoni}, 214, 562
carbohydrate recognition domains (CRD), 139
cats
canine influenza virus, 553
sporadic IAV infections in mammals, 559–561, 563f, 570–574
cDC see Centers for Disease Control and Prevention
cELISA see competitive ELISA
cell-mediated immunity (CMI), 136–137, 143
equine influenza virus, 528–529, 532–537
swine influenza virus, 452–453, 481–483, 495
centers for Disease Control and Prevention (CDC), 76–77
chitosan, 393
\textit{Chrotogale owstoni}, 214, 562
\textit{CV} see canine influenza virus
cloacal swabs, 31–32, 251
CMI see cell-mediated immunity
collectins, 139
community animal health workers (CAHW), 59–60
compensation, 61–62
competitive ELISA (cELISA), 254
control strategies
avian influenza virus, 363–377
biosecurity, 368–369
concepts and definitions, 363
decreasing host susceptibility, 370–371
diagnostics and surveillance methods, 369
economics of animal influenza, 371–373
education, communication, public awareness, and behavior change, 367–368
elimination of infected poultry, 369–370
goals and components, 366–371, 373–374
high-pathogenicity avian influenza viruses, 364–365
international animal health organizations, 373
low-pathogenicity avian influenza viruses, 363–364
production and marketing system changes, 368–369
public health, 372–373
vaccination, 369–370
cotton rat model, 602
CRD see carbohydrate recognition domains
\textit{Crocodile niloticus}, 581
culling
compensation, 62
control strategies, 369–370
costs of culling, disposal, and disinfection, 61
economics of animal influenza, 61–62
loss of production, 61–62
CVV see candidate vaccine viruses
\textit{Cygnus}, 560
D
DAILY see disability adjusted live years
\textit{Delphinapterus leucas}, 576
diagnostics and surveillance methods, 31–44, 607–608
characterization of influenza isolates, 40
concepts and definitions, 31
control strategies, 369
disease control, 229–235
education and training, 40
equine influenza virus, 514–516, 525–528, 531–532
global evolution of IAVs in swine, 459–462, 460f, 472
global nature of avian influenza, 177–180, 178f, 184, 192
H7 HPAIV in Australia (2012–2013), 261–263
H7N3 HPAIV outbreak in Mexico (2012–2014), 258–260
H7N7 HPAIV in Germany (2015), 267
H7N7 HPAIV in Italy (2013), 266
H7N7 HPAIV in Spain (2009), 257
H7N7 HPAIV in the UK (2008), 255–257, 256t
H7N7 HPAIV in the UK (2015), 266–267
H9N2 LPAIVs in live poultry markets, 274–275
public health, 94–95, 103, 107
sample collection, transport, and storage, 32–33
sample types, 31–32
sampling strategies, 228–229
swab pooling, 32f
swine influenza virus, 453–454, 496
vaccination, 381–383, 411–415, 496, 525–528, 531–532
virus detection, 33–40, 34f, 34t
see also individual methods
differentiating infected from vaccinated animals (DIVA)
avian influenza virus, 369, 379, 397, 412–415, 412f
equine influenza virus, 527–528, 536
disability adjusted live years (DALY), 46
disease control
Cambodia, 233
China, 233
Egypt, 234
European Union, 235
goose/Guangdong-lineage H5 HPAIV, 229–235
Hong Kong SAR, 230–231
Indonesia, 234
Japan, 234
Nigeria, 234–235
North America, 235
Republic of Korea, 233–234
Russia, 234
Thailand, 231–232
Vietnam, 232–233
disease harvesting, 366
DIVA see differentiating infected from vaccinated animals
DNA vaccines, 396–397, 495, 534–535
dogs
equine influenza virus, 510–511
sporadic IAV infections in mammals, 561–562, 564–566
see also canine influenza virus
domestic markets, 54–56

E
ECE see embryonated chicken egg
economics of animal influenza, 45–73
avoiding a human pandemic, 46
benefits and costs of controlling animal influenza, 46–49
concepts and definitions, 45–46
control strategies, 371–373
culling and compensation, 61–62
equine influenza virus, 508–509
food and livelihood insecurity, 56–58, 63
globalized livestock sector, 50, 50t
goose/Guangdong-lineage H5 HPAIV, 231
impacts of outbreak stamping-out measures, 58–64
improved livestock productivity through disease avoidance, 46–49
international markets, 52–54, 54f, 63
investment in animal health systems, 67–68
long-term measures for prevention and control, 66–68
market chains, 52, 53f
market shocks, 52–56
minimizing human disease contracted directly from livestock, 46
movement control, 60–61
pig production systems, 50–52, 50t, 61, 65, 67–68
post-outbreak rehabilitation, 64–66
potential impact of human influenza, 49–50
poultry production systems, 48–68, 50t, 51f
reporting and confirmation, 58–60
restructuring, 66–67
socio-economic effects of disease outbreak, 47f
timeline for H5N1 outbreak in Turkey, 58t
vaccination, 62–64
zoonotic and pandemic potential, 45–46, 46t, 49–50, 54
Egretta garzetta, 211
EHV-1 see recombinant equine herpesvirus type 1
EIV see equine influenza virus
elastase-dependent live attenuated vaccine, 493
ELLA see enzyme-linked lectin assay
EMA see European Medicines Agency
embryonated chicken egg (ECE), 33–35
enforcement capability, 59
Enhydra lutris kenyoni, 568
environmental tenacity, 316–317
enzyme-linked immunosorbent assay (ELISA)
equine influenza virus, 525, 527–528
ostrich H5N2 HPAIV infections in South Africa (2004–2011), 254
swine influenza virus, 454
vaccination, 381–383, 385–386, 413–414
virus detection, 36, 38
enzyme-linked lectin assay (ELLA), 40
epidemiology
adaptation and transmissibility, 313–314
avian influenza viruses in man-made systems, 10–13, 302–336
canine influenza virus, 551, 552–553
chickens, 302–305
commercial era chicken production, 303–305
canine influenza virus, 513–514
canine influenza virus, 513–514
exposure and transmission, 311–313, 313f
factors allowing transmission, 314–315
free-living aquatic birds as primordial reservoirs, 306–308, 320–325, 320f, 321f
history of humans and birds, 302–306
inactivation, 317–318
incubation and infectious periods, 315–316
infections within agricultural and man-made systems, 318–326, 320f
influenza A viruses in mammals, 308–310
lack of movement controls and biosecurity, 325
maintenance of AIVs in populations, 316–318
minor poultry, 306
modeling ecological factors, 325–326
outdoor rearing, 324
pathobiological concepts, 310–318, 311f, 312t
poultry and captive birds, 310
public health, 92–93, 93t, 103–106, 105f
shedding of virus and environmental tenacity, 316–317
species susceptibility, 324
sporadic human infections with HPAIVs, 310
sporadic infections in mammals with LPAIVs, 309–310
transmission of AIVs within/between enterprises/premises, 322–325
turkeys, 305
virulence and pathogenicity, 318
waterfowl, 305–306
equine influenza virus (EIV), 505–523
-cell-mediated immunity, 528–529, 532–537
-clinical features of infection and disease, 511–513, 511f, 512f
-commercial EIV vaccines, 533t
correlates of protection, 529
criteria and models of vaccine efficacy and protection, 525–526
diagnosis, treatment, and control, 514–516
diagnostics and surveillance methods, 525–528, 531–532
dNA vaccines, 534–535
economics of animal influenza, 45, 508–509
epidemiology, 513–514
genetics, 14
goals of vaccination, 524–525
herd immunity, 524–525
history, 505–508
host factors, 529
improving EIV vaccines and vaccine coverage, 538–540
mammalian experimental models, 604
maternal antibody interference, 529–530
modified-live virus vaccines, 527–528, 535–536
mucosal immunity, 530–531
phylogenetic tree of H3N8, 506–507f
poxvirus-based vaccines, 537–538
recombinant virus vaccines, 536–537
schedule for vaccination, 530
trade and food safety, 77–79
transmission to other mammalian hosts, 509–511
types of vaccines and administration, 532–538
updating vaccines, 531–532
vaccination, 508, 514–515, 524–546
Equus africanus asinus, 564
Escherichia coli, 85
ESNIP see European Surveillance Network for Influenza in Pigs
ethical considerations, 597
European Medicines Agency (EMA), 525, 531
European Pharmacopoeia, 486–487
European Surveillance Network for Influenza in Pigs (ESNIP), 464, 472

F
Falco peregrinus, 212
FAO see Food and Agriculture Organization of the United Nations
farrow-to-finish (FTF) farms, 446
ferret model, 441, 596f, 599–601, 600f
FMD see foot and mouth disease
Food and Agriculture Organization of the United Nations (FAO)
control strategies, 373
epidemiology in man-made systems, 306, 318
global evolution of IAVs in swine, 472
goose/Guangdong-lineage H5 HPAIV, 205
public health, 104
vaccination, 400
food insecurity, 56–58
food safety see trade and food safety
foot and mouth disease (FMD), 56
fowl plague, 178–179
frozen evolution, 508
FTF see farrow-to-finish

G
genetics
-antigenic drift and shift, 18–21, 207, 208, 219
-bat origin influenza, 10
cleavage site, 208, 208t
control strategies, 370, 372–373
deletions in virus proteins, 208–209
ecology in wild birds, 8–10
epidemiology in man-made systems, 10–13
equine and canine influenza, 14
goose/Guangdong-lineage H5 HPAIV, 204–209
H5N2 HPAIV in Chinese Taipei (2012), 264–265
H5N2 LPAIVs in commercial poultry production in Mexico, 284, 285f
H7 HPAIV in Australia (2012–2013), 263
H7N7 HPAIV in Germany (2015), 267
H7N7 HPAIV in Italy (2013), 266
H7N7 HPAIV in Spain (2009), 258
H7N7 HPAIV in the UK (2015), 267
H9N2 LPAIVs in live poultry markets, 272–274, 273f, 276f
influenza A virus, 8–14, 18–21
molecular markers of host range of H9N2 and H7N9 LPAIVs, 278–284
ostrich H5N2 HPAIV infections in South Africa (2004–2011), 251, 252f, 254
pathobiology of avian influenza in domestic ducks, 339–340, 341t
phylogenetic tree of Gs/Gd H5 HPAIV, 206, 207f
phylogenetic tree of H3N8, 506–507f
phylogenetic tree of H3N8 canine influenza virus, 550f
phylogenetic tree of H17N10 and H18N11 bat influenza viruses, 580f
phylogenetic tree of HA subtypes, 9f
phylogenetic tree of matrix gene, 11f
public health, 106–107, 114t
sporadic IAV infections in mammals, 579–580
swine influenza virus, 440–441
wild birds, 160–161
see also phylogenetic analysis
genome sequencing, 251, 252f
geometric mean titer (GMT), 386, 412
global nature of avian influenza
-concepts and definitions, 177–178
diagnostics and surveillance methods, 177–179, 178f, 184, 192
environmental reservoirs, 178, 180, 192
examples of LPAIVs in man-made systems, 183
features of LPAIVs, 184
fowl plague in poultry, 178–179
general history, 178–181, 193
goose/Guangdong-lineage H5 HPAIV, 181, 202–247
history of HPAI (1959–2015), 184–192, 185–191t
HPAIVs arising from H5/H7 LPAIVs, 180–181
LPAIV and HPAIV in wild birds, 180
LPAIV in poultry and captive birds, 182–184
Index 623

recognition of LPAI in poultry and other man-made systems, 179–180
regulatory aspects, 181–182
terminology, 182
Globicephala melaena, 576
GMT see geometric mean titer
goose feathers/down, 84
goose/Guangdong-lineage H5 HPAIV
anthropogenic factors, 223–224
antigenic drift and shift, 207, 208, 219
circulation of virus in China (1998–2000), 210
cleavage site, 208, 208t
collectors and definitions, 202–204
control strategies, 363–367, 370–373
deletions in virus proteins, 208–209
disease control, 229–235
distribution map (1996–2002), 211f
distribution map (2003–2004), 213f
distribution map (2005–2008), 215f
distribution map (2009–2012), 219f
distribution map (2013–2014), 221f
distribution map (2014–2015), 222f
domestic ducks, 220–222, 225
emergence of H5N1 viruses in China and Hong Kong SAR (1996–2002), 20, 181, 209–210
emergence of H5N1 virus into wider Asia (2003), 211–212
distribution map (2005–2008), 215f
distribution map (2009–2012), 219f
distribution map (2013–2014), 221f
distribution map (2014–2015), 222f
domestic ducks, 220–222, 225
future directions, 235–238
geneic studies and nomenclature, 204–209
global nature of avian influenza, 179, 181
global spread of Gs/GD-lineage H5 panzootic, 181, 209–223
migrations, 226, 227–228
multi-continental panzootic H5 HPAIV (1996–2015), 202–228
outbreaks in Hong Kong SAR/spread and evolution of virus in China (2001–2002), 210–211
pathology of H5 HPAI, 228
phylogenetic tree, 206, 207f
public health, 99–100, 107
Qinghai Lake and westward spread of virus (2005), 213–214
responses to outbreaks in Asia and viral evolution (2004), 212–213
restriction of virus to countries with entrenched infection (2011–2013), 220–221
sampling strategies, 228–229
seasonal effects, 227–228
severe acute respiratory syndrome, 212
sources of infection and reasons for spread, 223–228
spread of clade 2.3.1.2 and evolution of clade 2.3.4 (2008–2010), 217–220
temperature and festivals, 227
third wave of intercontinental spread (2014–2015), 221–223
trade in poultry and other birds, 77–78, 223–224
vaccination, 381, 385, 399–400, 408–411, 414–415
Z genotype virus, 211
Gs/GD see goose/Guangdong-lineage H5 HPAIV
Guillain–Barré syndrome, 111–112
guinea pig model, 596f, 601–602

H
H1N1 subtype influenza A virus
canine influenza virus, 553
diagnostics and surveillance methods, 35, 37, 454
economics of animal influenza, 45–46, 49–50, 54
epidemiology in man-made systems, 308–309, 312, 324
genetics, 12–13, 19–21
global evolution of IAVs in swine, 459–473, 461f
global nature of avian influenza, 184
history, 439
intervention strategies, 455
mammalian experimental models, 594, 601, 603, 607–608
molecular markers of host range, 281
public health, 92–94, 112, 114–116
sporadic IAV infections in mammals, 557, 565–576, 581
trade and food safety, 76–79
virology, 439
virus life cycle, 7
zoonotic transmission, 447
H1N1v influenza A virus, 114–116, 118
H1N2 subtype influenza A virus
genetics, 13
global evolution of IAVs in swine, 459, 461f, 462–466, 468
global nature of avian influenza, 184
trade and food safety, 79
vaccination, 480–481, 489–490, 493–494
virology, 439
H1N2v influenza A virus, 116, 118
H2N2 subtype influenza A virus
control strategies, 372–373
mammalian experimental models, 608
public health, 92
sporadic IAV infections in mammals, 574–575
H3N1 subtype influenza A virus, 565–566
H3N2 subtype influenza A virus
canine influenza virus, 552–553, 553f
clinical disease, 552, 553f
control strategies, 372–373
diagnostics and surveillance methods, 33–35, 454
emergence and spread, 552
epidemiology in man-made systems, 308–309
genetics, 13, 19–21
global evolution of IAVs in swine, 459–470, 461f
global nature of avian influenza, 184
infection of other hosts and re-assortments, 552
intervention strategies, 454–455
LPAIVs in live poultry assortments, 275
mammalian experimental models, 603, 608
H3N2 subtype influenza A virus (continued)
molecular markers of host range, 279
propagation, 6
public health, 92, 112–114, 114t
sporadic IAV infections in mammals, 565–567, 570, 573, 574–577, 581
swine influenza virus, 566–567
trade and food safety, 78–79
vaccination, 480–483, 485–495, 553
virology, 439
zoonotic transmission, 447
H3N2v influenza A virus, 112–114, 114t, 118
H3N8 subtype influenza A virus
canine influenza virus, 275, 308, 549–552, 604
clinical disease, 551–552, 551f
diagnosis and surveillance methods, 551–552
epidemiology, spread, and control, 308, 551, 552–553
genetics, 14, 21
history, 505–507, 510–511, 515
LPAIVs in live poultry markets, 275
mammalian experimental models, 604
phylogenetic tree, 550f
sporadic IAV infections in mammals, 564–565, 569
vaccination, 526, 528, 531–532, 535–537, 552
H4N5 subtype influenza A virus, 569
H4N6 subtype influenza A virus, 568
H4N8 subtype influenza A virus, 568
H5N1 subtype influenza A virus
antimicrobial resistance, 110
chest radiographic findings of H5N1 infection, 108f, 109f
clinical disease in poultry, 15
clinical management, 109–110
clinical presentation, 107–109
control strategies, 363–367, 370–373
diagnostics and surveillance methods, 36
economics of animal influenza, 45–46, 48–51, 53–54, 56–69
epidemic curve of human H5N1 HPAI cases, 105f
global nature of avian influenza, 179, 180–181, 192–193
goose/Guangdong-lineage H5 HPAIV, 202, 204–205, 223
immunity, 138, 141
mammalian experimental models, 598–605, 598t, 600f, 608
molecular markers of host range, 281, 283–284
pathogenesis, 110–111
public health, 93–94, 100, 102f, 103–111, 105f, 117–118
sporadic IAV infections in mammals, 557–564, 570–571
trade and food safety, 78–79, 81–86
transmission to humans, 105–108
virus life cycle, 7
wild birds, 153, 156, 163–164
H5N2 subtype influenza A virus
canine influenza virus, 553
clinical signs and description of affected population, 262
control measures, 265
diagnostics and surveillance methods, 258–261
epidemiology in man-made systems, 310, 312
goose/Guangdong-lineage H5 HPAIV, 205
HPAIV outbreak in Mexico (2012–2014), 258–261, 259t
public health, 98, 100–103
vaccination, 394, 398, 400–401, 404, 408
H7N7 subtype influenza A virus
clinical signs and description of affected population, 255, 257, 260–262, 265–266
control measures, 253–258, 266
diagnostics and surveillance methods, 255–257, 255t, 257, 261, 266
epidemiology in man-made systems, 308, 310
equine influenza virus, 14, 21, 604
genetics, 14, 21
global nature of avian influenza, 179, 180, 192
history, 505–507
HPAIV in Australia (2012), 260–262, 261t
HPAIV in Germany (2015), 267
HPAIV in Italy (2013), 265, 263t
HPAIV in Spain (2009), 257, 257t
HPAIV in the UK (2008), 254–257, 254t
HPAIV in the UK (2015), 266–267
mammalian experimental models, 598t, 601, 604
public health, 98, 100–103, 117
sporadic IAV infections in mammals, 570, 573f
trade and food safety, 79
vaccination, 380, 398, 408, 526, 531–532, 535–536
H7N9 subtype influenza A virus
control strategies, 363, 372
economics of animal influenza, 45–47, 54–56, 58–63, 68
epidemiology in man-made systems, 308, 309, 311, 314
global nature of avian influenza, 183
goose/Guangdong-lineage H5 HPAIV, 233, 236
low-pathogenicity avian influenza viruses, 278–284
mammalian experimental models, 594, 601–603
molecular markers of host range, 278–284
public health, 93–98, 117–118
trade and food safety, 78–79, 86
wild birds, 164
H9N1 subtype influenza A virus, 281
H9N2 subtype influenza A virus
control strategies, 363, 366–367, 372
economics of animal influenza, 45, 47
epidemiology in man-made systems, 308, 309, 312
global nature of avian influenza, 183
goose/Guangdong-lineage H5 HPAIV, 204, 218
immunity, 141
live poultry marketing, 272–275
low-pathogenicity avian influenza viruses, 272–284
mammalian experimental models, 601–602
molecular markers of host range, 278–284
phylogenetic tree, 273f, 276f
public health, 98–99
public health risks of H9N2 LPAIVs, 275, 277–278
sporadic IAV infections in mammals, 565
vaccination, 381, 385, 394, 403–404, 408
H10N4 subtype influenza A virus, 566
H10N7 subtype influenza A virus, 99–100, 566, 569–570
H10N8 subtype influenza A virus, 99–100, 117
H13N2 subtype influenza A virus, 576
H13N9 subtype influenza A virus, 576
H17N10 subtype influenza A virus, 156, 579–581, 580f
H18N11 subtype influenza A virus, 156, 579–581, 580f
HA see hemagglutinin
*Haemophilus parasuis*, 442

*Halichoerus grypus*, 569
hemagglutination inhibition (HI) assay
equine influenza virus, 527, 532, 536
global nature of avian influenza, 179
influenza A virus, 91
public health, 94–95
swine influenza virus, 454
vaccination, 411–412
virus detection, 35–37, 39
hemagglutinin (HA)
antigenic drift and shift, 19–21
bat origin influenza, 10
cellular pathology and hemagglutinin cleavage, 15
corona virus in wild birds, 8–10
epidemiology in man-made systems, 10–12
equine influenza virus, 505–508, 527–528, 537–538
global evolution of IAVs in swine, 459, 462–466, 470–471
global nature of avian influenza, 180
geese/Guangdong-lineage H5 HPAIV, 205–208, 207f, 212
H5N2 HPAIV in Chinese Taipei (2012), 263
hemagglutinin changes and pathogenicity, 16–17, 17t
immunity, 142–144
influenza A virus, 4–12, 15–17, 19–21
low-pathogenicity avian influenza viruses, 271, 278–280
mammalian experimental models, 596, 597f
pathobiology of avian influenza in domestic ducks, 339–340
phylogenetic tree of HA subtypes, 9f
proteolytic cleavage site, 279–280
public health, 94
receptor-binding site, 278–279
sporadic IAV infections in mammals, 580–581
swine influenza virus, 439–441, 445, 452, 481–483, 488, 494
wild birds, 159–160, 159t
hemagglutinin-neuraminidase (HN) proteins, 396
herd immunity, 524–525
high-pathogenicity avian influenza viruses (HPAIV)
antigenic drift and shift, 20–21
clinical disease in poultry, 15–18
corona virus, 234
concepts and definitions, 248–249
corona virus in mammals, 302, 304–308, 310–326
equine influenza virus, 505–507
global nature of avian influenza, 177, 179–182, 184–193, 185–191t
goose/Guangdong-lineage H5 HPAIV, 202–247
H5N2 HPAIV in Chinese Taipei (2012), 263–265, 265t
H7 HPAIV in Australia (2012–2013), 260–263, 261t
H7N3 HPAIV outbreak in Mexico (2012–2014), 258–260, 258t
H7N7 HPAIV in Germany (2015), 267
H7N7 HPAIV in Italy (2013), 265–266, 265t
H7N7 HPAIV in Spain (2009), 257, 257t
H7N7 HPAIV in the UK (2008), 254–257, 254t
high-pathogenicity avian influenza viruses (HPAIV) (continued)
H7N7 HPAIV in the UK (2015), 266–267
immunity, 138–142
mammalian experimental models, 594, 598–603, 605
ostrich H5N2 HPAIV infections in South Africa (2004–2011), 249–254, 249t
outbreaks since 2008, 248–270
pathobiology of avian influenza in domestic ducks, 337–354
propagation, 6
public health, 92–94, 100–111, 116–118
sporadic IAV infections in mammals, 557–564, 570–571
trade and food safety, 76–87
vaccination, 378–386, 392–395, 398–414
wild birds, 153, 156, 158–159, 161, 163–165
Hirundo rustica, 180, 259
HN see hemagglutinin-neuraminidase
horses
sporadic IAV infections in mammals, 564
trade and food safety, 74
see also equine influenza virus
HPAIV see high-pathogenicity avian influenza viruses
human influenza
economics of animal influenza, 49–50
epidemiology in man-made systems, 309
genetics, 13
global evolution of IAVs in swine, 462
goose/Guangdong-lineage H5 HPAIV, 202
mammalian experimental models, 603
sporadic IAV infections in mammals, 565–567, 569–570, 575–576
human-to-human transmission, 106, 215–216
humoral immunity, 452
Hylobates lar, 576
I
IAV see influenza A virus
IBV see influenza B virus
ICV see influenza C virus
IFN see interferons
IgA see immunoglobulin A
IgG see immunoglobulin G
IgM see immunoglobulin M
IL see interleukins
illega trade, 223–224
immune stimulating complex (ISCOM)-matrix vaccines, 393, 530–531, 534
immunity
adaptive immune responses, 135–137, 142–146
anatomy and physiology of avian immune system, 143–144
antigen-presenting cells, 139–140
antigen recognition and processing, 136, 142–146
assessment of vaccination and immunity, 411–412
avian influenza virus, 135–152
concepts and definitions, 135–137
control strategies, 370–371
herd immunity, 524–525
immunological basis for protection by vaccine, 380
inducible antimicrobial components, 139
innate immune responses, 135–142
interferons, 135, 137–139
mammalian experimental models, 601, 602
mucosal immunity, 145, 530–531
natural killer cells, 140–141
pathobiology, 340–345
polymorphonuclear leukocytes, 141–142
swine influenza virus, 452–453, 481–485
see also cell-mediated immunity; vaccination
immunoglobulin A (IgA), 144, 145, 484
immunoglobulin G (IgG), 452, 483–484, 532–533, 537
immunoglobulin M (IgM), 452
inactivated AIV vaccines, 384, 392
inactivated SIV vaccines, 480–481, 483–491, 486t, 487t
inducible antimicrobial components, 139
inducible nitric oxide synthase (iNOS), 141–142, 342
infectious bronchitis virus, 407
infectivity, 162
influenza A virus (IAV), 3–30
antigenic drift and shift, 18–21
bat origin influenza, 10
cellular pathology and hemagglutinin cleavage, 15
classification, 3–4
clinical disease in poultry, 14–18
composition, 4–5
concepts and definitions, 3
ecology and epidemiology, 3, 4f
ecology in wild birds, 8–10
epidemiology in man-made systems, 10–13
equine and canine influenza, 14
etiology, 3–6
field presentation, 14
genetics, 8–14, 18–21
hemagglutination inhibition assay, 5t
hemagglutinin changes and pathogenicity, 16–17, 17t
host/virus strain and pathogenicity, 15–16
molecular and biological features of LPAIVs and HPAIVs, 14–18
morphology, 5–6
nomenclature, 6
phylogenetic tree of HA subtypes, 9f
phylogenetic tree of matrix gene, 11f
propagation, 6
virus life cycle, 6–8
see also avian influenza virus; canine influenza virus;
equine influenza virus; individual virus subtypes; swine influenza virus
influenza B virus (IBV), 95
influenza C virus (ICV), 439
Influenza Risk Assessment Tool (IRAT), 118, 607–608
iNOS see inducible nitric oxide synthases
integrated fish farming, 272
interferons (IFN)
equine influenza virus, 528–529, 533–534
immunity, 135, 137–139
pathobiology of avian influenza in domestic ducks, 341–342
interleukins (IL), 135, 137, 528–529
international markets, 52–54, 54f, 63, 223
intravenous pathogenicity index (IVPI)
coloration of influenza isolates, 40
H7N7 HPAIV in the UK (2008), 255
low-pathogenicity avian influenza viruses, 271
osotorch H5N2 HPAIV infections in South Africa (2004–2011), 251
*in vitro* expressed viral proteins, 396
*in vivo* expressed hemagglutinin, 393–394
IRAT see Influenza Risk Assessment Tool
ISCOM see immune stimulating complex
IVPI see intravenous pathogenicity index

**J**
JAK/STAT pathway, 137–138

**L**
laboratory host systems, 441
LAIV see live attenuated influenza vaccines
*Lama* spp., 575–576
lateral flow device (LFD), 36
lectin histochemistry (LH) technique, 440
LFD see lateral flow device
LH see lectin histochemistry
licensed AI vaccines, 399–400, 401–402t
liposomes, 393
live AIV vaccines, 394–395
live attenuated influenza vaccines (LAIV)
elastase-dependent live attenuated vaccine, 493
modified non-structural protein NS1, 492
swine influenza virus, 491–493, 495–496
temperature-sensitive live attenuated vaccine, 492–493
livelihood insecurity, 56–58, 63
live poultry marketing (LPM)
control strategies, 364–366, 368–369, 372
epidemiology in man-made systems, 313, 318–319, 322–325
global nature of avian influenza, 177, 182–183, 192
influenza A virus, 12–13
low-pathogenicity avian influenza viruses, 272–275
live vectored vaccines, 384–385, 395–396, 400–404
low-pathogenicity avian influenza viruses (LPAIV), 271–301
clinical disease in poultry, 14–15, 17–18
concepts and definitions, 271
control strategies, 363–377
diagnostics and surveillance methods, 31–32, 37
economics of animal influenza, 45–47, 49, 54–56, 58–63, 68
epidemiology in man-made systems, 304, 366–369
global nature of avian influenza, 177–183, 192–193
goose/Guangdong-lineage H5 HPAIV, 205
H5N2 LPAIVs in commercial poultry production in Mexico, 284–285, 285f
H7N7 HPAIV in Spain (2009), 257–258
H7N7 HPAIV in the UK (2008), 254, 256
H9N2 LPAIVs in live poultry markets, 272–275
hemagglutinin, 271, 278–280
immunity, 136, 138–140
integrated fish farming, 272
live poultry marketing, 272–275
mammalian experimental models, 594, 598–602
matrix protein gene, 282
molecular markers of host range of H9N2 and H7N9 LPAIVs, 278–284
natural and agricultural host systems, 271–272
neuraminidase, 271, 280
non-structural protein gene, 282–283
nucleoprotein gene, 282
osotorch H5N2 HPAIV infections in South Africa (2004–2011), 251
pathobiology of avian influenza in domestic ducks, 338–344, 352–353
phylogenetic analysis of H5N2, 284, 285f
phylogenetic analysis of H9N2, 272–274, 273f, 276f
polymerase acidic protein, 282
polymerase basic proteins, 280–282, 283–284
propagation, 6
public health, 92–100, 116–118
public health risks of H9N2 LPAIVs, 275, 277–278
sporadic IA V infections in mammals, 565, 573f
trade and food safety, 76–87
vaccination, 379–385, 392–394, 398–414
virus life cycle, 8
wild birds, 154–155, 158–159, 163–165, 271–272
LPM see live poultry marketing

**M**
M1 see matrix protein
M2 see membrane ion channel
*Macaca* spp., 576, 603
macrophages, 139–140
Madin–Darby canine kidney (MDCK) cells
diagnostics and surveillance methods, 33–35
equine influenza virus, 514–515, 525
swine influenza virus, 439–440, 453
maintenance cycle, 162
major histocompatibility complex (MHC), 370, 533–534
mammalian experimental models, 594–617
advantages and disadvantages of particular species models, 596f
aerosol inhalation, 604–605
concepts and definitions, 594
cotton rat model, 602
determination of pandemic potential, 608–609
differential virulence by species, 598t
efficacy of antiviral treatments, 607, 608
ethical considerations, 597
evaluation of vaccines and vaccine candidates, 606–607
experimental readout, 593–596
facilities, 595
factors affecting model selection, 595–597
ferret model, 596f, 599–601, 600f
guinea pig model, 596f, 601–602
host responses to infection, 601–602, 603–604
immunity, 601, 602
influenza virus pathogenesis, 598–603
influenza virus transmission, 601–603
inoculation route and dose, 604–605
modulation of liquid instillation, 604
mammalian experimental models (continued)
mouse model, 596f, 598–599
non-human primate model, 603–604
ocular inoculation, 605
pig model, 602–603
public health, 606–609
receptor-binding specificity and virus attachment, 596, 597f
research platforms, 595f
role of environmental conditions, 608
sample size and statistical power, 597
surveillance and risk assessment, 607–608
traditional intranasal and intratracheal inoculation, 597–605
transgenic mice, 599
Marek’s disease herpesvirus (MDV), 406–407
market chains, 52, 53f
market shocks, 52–56, 54f
Martes foina, 562–563
maternally derived antibodies (MDA)
equine influenza virus, 529–530
swine influenza virus, 440, 446–447, 453, 484, 493–495
maternally derived immunity (MDI), 453
matrix genes, 453–454
matrix metalloproteases (MMP), 141
matrix protein (M1), 4, 8, 282
maximum likelihood trees, 252f
MDA-5 see melanoma differentiation associated protein-5
MDA see maternally derived antibodies
MDCK see Madin–Darby canine kidney
MDI see maternally derived immunity
MDP see muramyl dipeptide
MDV see Marek’s disease herpesvirus
melanoma differentiation associated protein-5 (MDA-5), 137–138, 341–342
Meleagrīs gallopavo spp., 305
membrane ion channel (M2) proteins, 4, 7–8
Mephitis, 568–569
MHC see major histocompatibility complex
microneutralization (MN) test, 95
milk drop syndrome, 575
Mirounga angustirostris, 568, 570
MLV see modified-live virus
MMP see matrix metalloproteases
MN see microneutralization
modified-live virus (MLV) vaccines, 527–528, 535–536
mouse model, 596f, 598–599
movement control, 60–61
mucosal immunity, 145, 530–531
muramyl dipeptide (MDP), 393
Mus musculus, 581, 596f, 598–599
Mustela spp., 562–563, 566–568, 574, 596f, 599–601, 600f
Mycoplasma hypovirumae, 442, 444–445, 454
Myrmecophaga tridactyla, 581
N
NA see neuraminidase
National Directorate of Animal Health, 250
National Food Quality, Food Safety and Health Service (SENASICA), 260
National Poultry Improvement Plan (NPIP), 177–178, 178f
natural killer (NK) cells, 140–141, 453
NDV see Newcastle disease virus
NEP see nuclear export protein
neuraminidase inhibition (NI) assay, 36–37, 39–40, 483–484
neuraminidase (NA)
antigenic drift and shift, 19
bat origin influenza, 10
culture strategies, 364
ecology in wild birds, 8–10
epidemiology in man-made systems, 10–12
equine influenza virus, 505–508, 528
global evolution of IAVs in swine, 459, 465, 471
global nature of avian influenza, 180
goose/Guangdong-lineage H5 HPAIV, 203, 205–206, 208–209
H5N2 HPAIV in Chinese Taipe (2012), 263
influenza A virus, 4, 8–12, 19
low-pathogenicity avian influenza viruses, 271, 280
pathobiology of avian influenza in domestic ducks, 340
public health, 94
sporadic IAV infections in mammals, 580–581
swine influenza virus, 452, 481–484
vaccination, 380, 392, 395–396, 414–416
wild birds, 159–160
Newcastle disease virus (NDV), 179, 379, 395–396, 407
NHP see non-human primates
NI see neuraminidase inhibition
nitric oxide (NO), 141–142, 342
NK see natural killer
NO see nitric oxide
non-human primates (NHP), 576–577, 577t, 578t, 603–604
non-structural proteins (NS1/2)
equine influenza virus, 527, 536
influenza A virus, 4
low-pathogenicity avian influenza viruses, 282–283
pathobiology of avian influenza in domestic ducks, 340
sporadic IAV infections in mammals, 581
vaccination, 415, 492
NP see nucleoprotein
NPIP see National Poultry Improvement Plan
NS1/2 see non-structural proteins
nuclear export protein (NEP), 4, 8
nucleoprotein (NP)
equine influenza virus, 528
global evolution of IAVs in swine, 466
low-pathogenicity avian influenza viruses, 282
pathobiology of avian influenza in domestic ducks, 340
swine influenza virus, 445, 452–454
Nyctereutes procyonoides, 562
O
Ochotona curzoniae, 564
Odobenus rosmarus divergens, 570
Office International des Epizootics see World Organization for Animal Health
OIE see World Organization for Animal Health
oil adjuvants, 392–393, 488
open reading frame-1 (ORF-1), 538
opharyngeal swabs, 31–32
Oryctolagus cuniculus, 564, 581
oseltamivir, 110
ostrich H5N2 HPAIV infections
   Eastern Cape Province outbreak (2004), 249–250
genome sequencing, 251, 252f
   South Africa (2004–2011), 249–254, 249t
   Western Cape Province outbreak (2004), 250–251
   Western Cape Province outbreak (2006), 251
   Western Cape Province outbreak (2011), 251–254

P
   PA see polymerase acidic protein
   Paleosuchus trigonatus, 581
   PAMP see pathogen-associated molecular patterns
   pandemic H1N1 (pH1N1) virus
      canine influenza virus, 553
economics of animal influenza, 49–50, 54
   genetics, 13, 20–21
   mammalian experimental models, 594, 607
   public health, 92–93, 112
   sporadic IAV infections in mammals, 557, 565–576
   vaccination, 481, 485–494
   Panthera spp., 555, 558, 562f
   Pan troglodytes, 577
   Papio spp., 576–577
   Passer montanus, 212, 322
   pasteurization, 83–84, 84t
   pathobiology
      adaptation and transmissibility, 313–314
      avian influenza in domestic ducks, 337–362
      clinical signs of Gs/GD H5N1 HPAIV, 347–350, 347–351f
      clinical signs of HPAIV in domestic ducks, 344
   pathogen-associated molecular patterns (PAMP), 135–136, 140
   pathogen recognition receptors (PRR), 341

PCV2 see porcine circovirus
Pelacanus occidentalis, 156
pentraxins (PTX), 139
   peripheral blood mononuclear cells (PBMC), 528, 537–538
   personal protective equipment (PPE), 111
   pH1N1 see pandemic H1N1
   Phoca groenlandica, 569
   Phocoenoides dalli, 576
Phylo pneumoideas allii, 576
   phylogenetic analysis
      equine influenza virus, 506–507f
      goose/Guangdong-lineage H5 HPAIV, 206, 207f
      H3N8 canine influenza virus, 550f
      H5N2 LPAIVs in commercial poultry production in Mexico, 284, 285f
      H7 HPAIV in Australia (2012–2013), 263
      H7N7 HPAIV in Italy (2013), 266
      H7N7 HPAIV in Spain (2009), 258
      H9N2 LPAIVs in live poultry markets, 272–274, 273f, 276f
      ostrich H5N2 HPAIV infections in South Africa (2004–2011), 254
      sporadic IAV infections in mammals, 564, 567, 579–580, 580f
   pigs
   economics of animal influenza, 50–55, 50t, 55f, 61, 65, 67–68
   equine influenza virus, 511
   goose/Guangdong-lineage H5 HPAIV, 212
   mammalian experimental models, 602–603
   trade and food safety, 74
   see also swine influenza virus
   POC see point-of-care
   Podiceps grisegena, 156
   point-of-care (POC) testing, 95
   polymerase acidic protein (PA)
      influenza A virus, 4–5
      low-pathogenicity avian influenza viruses, 282
   pathobiology of avian influenza in domestic ducks, 340
   swine influenza virus, 441, 462–463, 471
   polymerase basic proteins (PB1/2)
      influenza A virus, 4–5
      low-pathogenicity avian influenza viruses, 280–282, 283–284
      swine influenza virus, 441, 462–463, 470–471
   polymorphonuclear leukocytes, 141–142
   porcine circovirus (PCV2), 454–456
   porcine reproductive and respiratory syndrome virus (PRRSV), 442
   porcine reproductive respiratory syndrome virus (PRRSV), 454–456
   porcine respiratory disease complex (PRDC), 440, 442, 470
   poultry
      cellular pathology and hemagglutinin cleavage, 15
      clinical disease in, 14–18
      control strategies, 364–366, 368–372
      economics of animal influenza, 48–68, 50t, 51f, 55f
      epidemiology in man-made systems, 302–306, 310, 313, 318–325
      field presentation, 14
   genetics, 12–13
poultry (continued)
global nature of avian influenza, 177–181, 182–184
hemagglutinin changes and pathogenicity, 16–17, 17t
host/virus strain and pathogenicity, 15–16
immunity, 137–146
influenza A virus, 12–18
low-pathogenicity avian influenza viruses, 272–275, 284–285
molecular and biological features of LPAIVs and HPAIVs, 14–18
public health, 93, 95, 97–111, 116–118
trade and food safety, 74
vaccination, 378–434
viruses shared with wild birds, 163–164
poxvirus-based vaccines, 537–538
PPE see personal protective equipment
PRDC see porcine respiratory disease complex
Procyon lotor, 563, 568
proteolytic cleavage site, 279–280
PRR see pattern recognition receptors
PRRSV see porcine reproductive and respiratory syndrome virus
PTX see pentaxins
public health, 92–132
chest radiographic findings of fatal H5N1 infection, 108f, 109f
control strategies, 372–373
diagnosis of animal-origin IAV infections, 94–95, 103, 107
epidemic curve of human H5N1 HPAI cases, 105f
geographic distribution of H5N1 HPAI cases, 102f
goose/Guangdong-lineage H5 HPAIV, 203–204
H9N2 LPAIVs in live poultry markets, 275, 277–278
human infections by influenza A variant viruses, 111–116, 118–119
H1N1 variant viruses, 112, 114–116, 118
H3N2 variant viruses, 112–114, 114t, 118
human infections with HPAIVs, 100–111, 101t, 116–118
H5N1, 100, 102f, 103–111, 105f, 117–118
H5N6, 103–111
H7NX, 100–103
human infections with LPAIVs, 95–100, 96t, 116–118
H6N1, 100, 117
H7N9, 95–98
H7NX, 98, 117–118
H9N2, 98–99
H10NX, 99–100, 117
human-to-human transmission, 106
mammalian experimental models, 606–609
recommended measures for responders to LPAI and HPAI outbreaks, 111
vaccination, 111–112, 118
zoonotic and pandemic potential, 92–93, 93t

Q
quarantine, 515
Quiscalus spp., 180, 259

R
radiography, 108f, 109f
Rattus norvegicus, 564, 581
RBS see receptor-binding site
reactive oxygen species (ROS), 141–142
real-time RT-PCR see reverse transcription–polymerase chain reaction
receptor-binding site (RBS), 278–279, 596, 597f
recombinant equine herpesvirus type 1 (EHV-1), 538
recombinant fowl poxvirus (rFPV), 384–385, 395–396, 400–404
recombinant herpesvirus turkey (rHVT), 384, 395–396, 403–404
recombinant Newcastle disease virus (rNDV), 384, 395–396, 403–404
recombinant protein vaccines, 494
recombinant virus vaccines, 536–537
rehabilitation
biosecurity in farms and markets, 65–66
economics of animal influenza, 64–66
restocking, 64–65
reporting
compulsory disease reporting, 59
domestic markets, 54–56
economics of animal influenza, 58–60
effective animal health information system, 59–60
farmer awareness of disease-reporting pathways, 59
incentives to report, 59
laboratory staff and facilities, 60
legislative back-up and enforcement capability, 59
restocking, 64–65
restructuring, 66–67
retinoic acid-inducible gene-I (RIG-I), 137–140, 341–342, 352
reverse transcription–polymerase chain reaction (RT-PCR) control strategies, 369
equine influenza virus, 515
goose/Guangdong-lineage H5 HPAIV, 229
H7N7 HPAIV in Spain (2009), 257
public health, 94–95, 111
sample collection, transport, and storage, 32–33
sample types, 31–32
swine influenza virus, 453–454
vaccination, 381–383, 386, 413
virus detection, 35, 36–37
rFPV see recombinant fowl poxvirus
rHVT see recombinant herpesvirus turkey
RIG-I see retinoic acid-inducible gene-I
rimantadine, 110
ring vaccination, 524
RNA replicon particles (RP), 493–494
rNDV see recombinant Newcastle disease virus
ROS see reactive oxygen species
RP see RNA replicon particles
RT-PCR see reverse transcription–polymerase chain reaction

RT-PCR see reverse transcription–polymerase chain reaction
S

S see sialic acid

Saimiri sciureus, 577, 603

Salmonella spp., 82–83, 85t

Sample size, 597

Saponins, 393

SARS see severe acute respiratory syndrome

SENOSICA see National Food Quality, Food Safety and Health Service

Sentinel system, 414

Serological testing

Control strategies, 369

Equine influenza virus, 525, 527–528

Global nature of avian influenza, 177–178

H7N7 HPAIV in the UK (2008), 256, 259t

H9N2 LPAIVs in live poultry markets, 275


Public health, 103, 107

Sporadic IAV infections in mammals, 560–561, 564, 568, 571–581, 571–572t

Swine influenza virus, 454

Vaccination, 381–383, 385–386, 412f, 413–415, 413t

Virus detection, 35, 38–40

Severe acute respiratory syndrome (SARS), 49–50, 212

Sialic acid (SA)

Immunity, 140

Influenza A virus, 7

Mammalian experimental models, 596, 597t, 602–603

Sigmodon hispidus, 602

Silent infections, 397

SirNA see small interfering RNA

SIV see swine influenza virus

Small interfering RNA (siRNA), 370

Songbird trade, 224

Spanish flu epidemic (1918)

Epidemiology in man-made systems, 309

Immunology, 138

Influenza A virus, 13

Low-pathogenicity avian influenza viruses, 282, 283

Swine influenza virus, 439, 459

Sporadic IAV infections in mammals, 557–593

Concepts and definitions, 557

Family Ailuridae, 566

Family Canidae, 561–562, 564–566

Family Felidae, 558–561, 570–574

Family Mephetidae, 568–569

Family Mustelidae, 562–563, 566–568

Family Phocidae, Odobenidae, and Otariidae, 569–570, 571–572t

Family Procyonidae, 563, 568

Family Ursidae, 566

Family Viverridae, 568, 574

H5N1 HPAIV infections, 557–564

Order Artiodactyla (non-swine species), 564, 574–576

Order Carnivora, suborder Caniformia, 564–570

Order Carnivora, suborder Feliformia, 570–574

Order Cetacea, 576

Order Chiroptera, 577–581

Order Primates/non-human primates, 576–577, 577t, 578t

Order Rodentia and Lagomorpha, 564, 581

Other IAV infections, 564–581

Virological evidence, 559t, 560t, 561t

Statistical power, 597

Sterile immunity, 524

Sterna hirundo, 153, 321–322, 338

Surveillance see diagnostics and surveillance methods

Sus scrofa see pigs; swine

Swab pooling, 32f

Swine influenza virus (SIV), 439–451

Antigenic evolution of IAV in swine, 466–467

Asia, 465–466

Clinical disease, 441–442

Commercial inactivated SIV vaccines, 485–491, 486t, 487t

Concepts and definitions, 439, 459–462

Determinants of virulence and host range, 469–472


DNA vaccines, 495

Efficacy of SIV vaccines in Europe, 489–490

Efficacy of SIV vaccines in North America, 490–491

Epidemiology in man-made systems, 308–309

Europe, 463–465

Genetics, 12–13

Geographic distribution of swine IAV genotypes, 461f, 462–466

Global evolution of IAVs in swine, 459–479

Global nature of avian influenza, 183

Global nature of swine influenza, 481

Gross pathology, 444–445, 445f

History, 439, 459

Immune response to inactivated SIV vaccine, 483–485

Immune response to infection with live, wild-type SIV, 481–483

Immunology, 452–453

Immunohistochemistry, 445–446

Intervention strategies, 454–456

Laboratory host systems, 441

Live attenuated influenza vaccines, 491–493, 495–496

Major SIV lineages in Europe and North America, 482t

Mammalian experimental models, 603

Microscopic pathology, 442–443, 443f, 444f

North America, 462–463

Novel SIV vaccines, 491–495

Pathobiology of IAV in pigs, 442–446

Pathogenicity, 440–441

Public health, 92–94, 111–119

Recombinant protein vaccines, 494

Regulatory aspects and vaccine strain selection, 486–489, 495–496

RNA replicon particles, 493–494

SIV evolution and vaccine immunology, 481–485

South America, 463

Sporadic IAV infections in mammals, 566–568

Swine in IAV ecology and host species interactions, 467–469, 469f

Trade and food safety, 77–79

Transmission and epidemiology of IAV in pigs, 446–447

Vaccination, 435–456, 472, 480–501

Vaccine characteristics and composition, 485–486
swine influenza virus (SIV) (continued)
  vector vaccines, 494–495
  virology, 439–441
  virus life cycle, 7
  zoonotic infections, 447, 467–469, 469f

T
  Taxidea taxus, 568, 574
  TBA see thiobarbituric acid
temperature-sensitive live attenuated vaccine, 492–493
  thiobarbituric acid (TBA) assay, 40
  TLR see toll-like receptors
  T-lymphocytes
    equine influenza virus, 528, 532, 537
    immunity, 135–137, 144–145
    swine influenza virus, 453, 483
    vaccination, 392–393, 395
  TNF see tumor necrosis factor
toll-like receptors (TLR)
  immunity, 135–136, 140, 144–145
  pathobiology of avian influenza in domestic ducks, 341–342
trade and food safety, 74–91
  egg products, 83–84
  food safety risks, 84–86
  global production of agricultural animals and products, 74, 75t
  goose/Guangdong-lineage H5 HPAIV, 223–224
  inactivation methods for IA Vs in animal products, 82–84, 84t
  influenza A viruses as non-tariff trade barrier, 76–77
  levels of risk for spread, 80–82, 81t
  meat and related products, 82–83
  mitigation of trade risks, 82–84
  pathogenesis of IAVs and trade risk, 77
  reducing live animal trade risk, 82
  risk of IAVs to humans through trade, 78–79
  risk of spread of IAVs through trade, 79–80
  risks for spread of IAVs to animals through trade, 77–78
  standards for safe trade, 74–76
  vaccination, 81t, 82
  transcription factors, 136
  transgenic mice, 599
  triple reassortant internal gene (TRIG) cassette, 13, 115–116
  global evolution of IAVs in swine, 462
  swine influenza virus, 439
  tumor necrosis factor (TNF), 528

U
  United Nations FAO see Food and Agriculture Organization of the United Nations
  United States Department for Agriculture (USDA)
    trade and food safety, 83, 83t, 84t
    vaccination, 487, 525–526, 531

Ursus arctos, 566

V
  vaccination
    adjuvants, 392–393, 406, 488
    alimentary administration, 407
  antigenic matching of the seed strain, 405, 488
  assessment of vaccination and immunity, 411–412
  avian influenza in poultry, 378–434
  biosecurity, 411
  broad homosubtypic protection, 404
  canine influenza virus, 552, 553
  categories of avian influenza vaccines, 386, 387–391t
  cell-mediated immunity, 528–529, 532–537
  commercial EIIV vaccines, 533t
  commercial inactivated SIV vaccines, 485–491, 486t, 487t
  concepts and definitions, 378, 480–481
  control strategies, 369–370
  correlates of protection, 529
  cost-effectiveness, 63, 64
  criteria and models of vaccine efficacy and protection, 525–526
  diagnostics and surveillance methods, 381–383, 411–415, 496, 525–528, 531–532
  direct assessment of protection, 380–385, 381–383t, 382f
  DIVA strategy, 369, 379, 397, 412–415, 412f, 527–528, 536
  DNA vaccines, 396–397, 495, 534–535
  doses administered globally, 403–404, 403f
  economics of animal influenza, 62–64
  efficacy of SIV vaccines in Europe, 489–490
  efficacy of SIV vaccines in North America, 490–491
  epidemiology in man-made systems, 304
  equine influenza virus, 508, 514–515, 524–546
  experimental studies and parameters, 384–385, 387–391t
  field application method and coverage, 408–411
  field use of vaccine and special issues, 397–411
  funding sources, 63–64
  global nature of avian influenza, 192
  goals, 524–525
  H7N3 HPAIV outbreak in Mexico (2012–2014), 259
  herd immunity, 524–525
  history of avian influenza vaccines, 378–379
  host factors, 529
  immune response to inactivated SIV vaccine, 483–485
  immune stimulating complex-matrix vaccines, 393, 530–531, 534
  immunological basis for protection, 142, 380
  improving EIIV vaccines and vaccine coverage, 538–540
  indirect assessment of protection, 385–386
  in ovo administration, 406–407
  in vitro expressed viral proteins, 396
  in-vivo expressed hemagglutinin, 393–394
  laboratory criteria for assessing vaccine protection, 380–386
  licensed AI vaccines, 399–400, 401–402t
  liposomes, 393
  live AIV vaccines, 394–395
  live attenuated influenza vaccines, 491–493, 495–496
  livelihood insecurity, 63
  live vectored vaccines, 384–385, 395–396, 400–404
  mammalian experimental models, 606–607
  management and environmental conditions, 407–408
  mass administration, 406–407
  maternal antibody interference, 529–530
  modified-live virus vaccines, 527–528, 535–536
mucosal immunity, 530–531
novel SIV vaccines, 491–495
oil adjuvants, 392–393, 488
priorities for vaccination, 411
potency, 386
poxvirus-based vaccines, 537–538
prevention of contact transmission, 383–384, 383t
production systems, 64
properties of ideal AI vaccine for birds, 379–380, 380t
public health, 111–112, 118
quality control, 404–406
recombinant protein vaccines, 494
recombinant virus vaccines, 536–537
recombinant protein vaccines, 494
route of administration, 406–407, 480, 483–484, 530–538
seed strains, 398–404
selection criteria, 398–399
sentinel system, 414
serological surveillance, 412f, 413–415, 413t
sero logical surveillance, 412f, 413–415, 413t
SIV evolution and vaccine immunology, 481–485
swine influenza virus, 441, 455–456, 472, 480–501
technical viability, 63
time of administration, 406–407, 480, 483–484, 530–538
trade and food safety, 81t, 82
types of avian influenza vaccines, 386–397
types of equine influenza vaccines, 532–538
updating vaccines, 531–532
vaccine characteristics and composition, 485–486
vaccine vectors, 494–495
virological surveillance, 412–413, 412f
vaccine-associated enhanced respiratory disease (VAERD), 440
vaccine vectors, 494–495
VI see virus isolation
Vicugna, 575–576
viral antigen staining, 347–350, 348–351f
viral shedding, 161–162
virological surveillance, 412–413, 412f
virus isolation (VI)
public health, 94–95
sample collection, transport, and storage, 32–33
sample types, 31–32
swine influenza virus, 453
virus detection, 33–36
virus neutralization (VN) assay, 481–484
Vulpes vulpes, 562

WHO see World Health Organization
wild birds, 153–176
control strategies, 363–366
environmental factors affecting viral infectivity, 162
environmental reservoirs, 156–157, 162
epidemiology in man-made systems, 306–308, 320–325, 320f, 321f
free-living aquatic birds as primordial reservoirs, 306–308, 320–325, 320f, 321f
future directions, 164–165
genetic diversity, 160–161
global nature of avian influenza, 180–181
H5N1 HPAIV, 153, 156, 163–164
H7N3 HPAIV outbreak in Mexico (2012–2014), 259
host factors affecting susceptibility and viral shedding, 161–162, 161f
host range, 153–156, 154–155t
influenza A virus, 8–10
low-pathogenicity avian influenza viruses, 271–272
maintenance cycle, 162
mechanisms for AIV maintenance and transmission, 161–162, 161f
public health, 107
spatial and temporal variation in AIV infection, 157–158
species susceptibility, 156
subtype diversity, 159–160, 159f
susceptibility to subsequent infections, 158–159
transmission cycle, 161
viruses shared with poultry, 163–164
World Health Organization (WHO)
equine influenza virus, 531
goose/Guangdong-lineage H5 HPAIV, 205
H9N2 LPAIVs in live poultry markets, 277
public health, 92, 109–110
trade and food safety, 76–77
World Organization for Animal Health (OIE)
control strategies, 37, 364
equine influenza virus, 515, 531
global evolution of IAVs in swine, 472
global nature of avian influenza, 181–182
goose/Guangdong-lineage H5 HPAIV, 205, 209
H7N3 HPAIV outbreak in Mexico (2012–2014), 258–260
Terrestrial Animal Health Code, 248, 271
trade and food safety, 74–77, 84
vaccination, 397
World Trade Organization (WTO), 74–76

X
X-ray surveillance, 232

Y
years of life lost (YLL), 46

Z
Z genotype virus, 211
zoonotic infections
chest radiographic findings of H5N1 infection, 108f, 109f
economics of animal influenza, 45–46, 461, 49–50, 54
epidemic curve of human H5N1 HPAI cases, 105f
epidemiology in man-made systems, 308–310
equine influenza virus, 509–511
geographic distribution of H5N1 HPAI cases, 102f
global evolution of IAVs in swine, 467–469, 469f
goose/Guangdong-lineage H5 HPAIV, 202–247
zoomotic infections (continued)
human infections by influenza A variant viruses, 111–116, 118–119
H1NX variant viruses, 112, 114–116, 118
H3N2 variant viruses, 112–114, 114t, 118
human infections with HPAIVs, 100–111, 101t, 116–118
H5N1, 100, 102f, 103–111, 105f, 117–118
H5N6, 103–111
H7NX, 100–103
human infections with LPAIVs, 95–100, 96t, 116–118
H6N1, 100, 117
H7N9, 95–98
H7NX, 98, 117–118
H9N2, 98–99
H10NX, 99–100, 117
human-to-human transmission, 106
mammalian experimental models, 608–609
public health, 92–132, 93t
recommended measures for responders to LPAI and HPAI outbreaks, 111
sporadic IAV infections in mammals, 557–593
swine influenza virus, 447
vaccination, 111–112, 118