Index

acellular afibrillar cementum (AAC), 51
acellular cementum, 50–1
  evidence of onset of puberty, 245
  formation of, 47, 50
  identifying parturition lines in acellular cementum, 234–46
  phosphate metabolism, 67–70, 76
  potential insights from mouse genetic models, 75–7
  pyrophosphate regulation of cementogenesis, 70–3, 76
  role of ECM proteins, 73–5
acellular cementum increments composition study
  aim of the study, 110–11
  cementum–dentin junction identification, 116–18
  cementum mineralization front identification, 116–18
  comparison of band structures from X-rays and optical microscopy, 124–9
  compositional differences and the band structure, 135
  crystallographic texture within cementum, 129–34
  elemental signature of cementum and dentin, 127–9
  methods, 112–15
  protocol improvements for microstructure analysis, 134–5
  reasons for differences between X-ray and optical microscopy results, 127–34
  reference collections, 111–12
  results, 115–29
  synchrotron sample preparation and microbeam sampling, 112–15
  thin-section preparation and optical microscopy, 112–13
  X-ray signals and band structure in cementum, 118–25
  X-ray signals and the dental structures, 116–18
acellular extrinsic fiber cementum (AEFC). *See* acellular cementum
Ache people of Paraguay, 329
acromegaly
  association with hypercementosis, 100–1
adaptive cementum. *See* cellular cementum
age-at-death distribution
  Early Medieval population
    advantages and limitations of the TCA method, 375–6
    approach to reconstruction in a past population, 364–5
    benefits of a study design using combined methods, 375–6
    comparison of aging methods, 364–5
    comparison of methods of age estimation, 369–70
    Complex Method for age-at-death estimation, 366
    distribution of individual age estimates, 368
    graveyard at Lauchheim, Germany, 365
    interobserver variation, 368–9
    interpretation of distributions from different methods, 373–5
    material and methods, 365–8
    morphological age estimation (MAE) methods, 366
    resulting distribution by each method, 371–3
    results, 368–73
    sample selection, 365–6
    TCA method of age-at-death estimation, 366–8
  fisher-gatherer population in Brazil, 322–33
  for past populations
    challenges of individual age assessment, 338–9
    considerations when using cementochronology, 346–8
    data set comparisons, 342
    dental material analysis, 341–2
    dental material selection, 340–1
    historical archives analysis, 340
    materials and methods, 339–42
    Notre-Dame du Bourg Cathedral death registers, 340
    probabilistic method, 342
    range of methods of age estimation, 338–9

reconstruction of the mortality profile, 346–7
reference collection of Notre-Dame du Bourg Cathedral, France, 339–40
results, 342–6
use of cementochronology for individual age estimation, 339
value of cementochronology as a paleodemographic tool, 347–8
Nabataean burials at Petra, Jordan, 351–61
age-at-death estimation
dental eruption charts, 216
development of cementum analysis protocol, 30–6
human deciduous teeth age-at-extraction study, 215–24
identification of US POW/MIA service members, 226–32
London Atlas of Human Tooth Development, 216
search for the ideal skeletal age indicator, 386–9
validation studies, 31–6
age estimation
Bayesian approach, 388
biological clocks, 387
correlation of cementum thickness with age in humans, 28–9
history of the use of cementum, 2–3
limitations of markers of biological aging, 10–11
use of bone remodeling in humans, 8
age identities
aging process
influence of individual variations in cementum studies, 166
Agta people of the Philippines, 329
alligators, 86–7
alpacas, 87
ALPL gene, 84–5
ALPL gene mutations, 72
ALPL knock-out mice, 72
amphibians
annual growth pattern, 7
anatomically modern humans (AMH)
hominin strategies in southern Belgium (Late Pleistocene), 288–302
animal studies
history of use of cementum for age estimation, 2
hormonal physiology and cementum growth, 157–9
wildlife and zoo studies of cementum annulation, 29–30
ANK gene mutations, 72–3
ANK mutant or knock-out mice, 72–3
annual rhythms. *See* circannual rhythms
annuli, 2
antemortem loss of antagonistic teeth
influence on cementum deposition, 99
anthropology, 3, 7
antiresorptive therapies
risk of osteonecrosis of the jaw, 59
apical periodontitis
influence on cementum deposition, 98
archeological studies, 30
archeology
diagenetic and taphonomic effects on tooth cementum, 148–50
ARNTL gene, 86
automated counting of increments, 384

baboons, 85
bald eagles, 87
barren-ground caribou, 202
bats, 87
Bayesian approach to age estimation, 388
Bayesian inference procedure, 338
bears, 9, 30, 38, 380
beluga whales, 6
biological clocks. *See* chronobiology
bison, 29, 30, 276–80
black bears, 148, 158
Black, G. V., 26
Blake, Robert, 23–5
BMP-2 gene, 85
BMP-7 gene, 85
bone
cyclical growth patterns, 7–8
properties compared with cementum, dentin, and enamel, 54
bone deposition and mineralization
circadian rhythms, 6
bone morphogenic protein (BMP)
genes associated with, 85
bone sialoprotein (BSP), 49, 53–4, 73, 163
role in cementogenesis, 73–5
Brazil
pre-farming population demography, 322–33
broad and translucent annulations (BTAs), 159–61
BSP gene, 90
buffalo, 29
bushbuck, 29

calcinosis, 102
calcium
concentrations in chimpanzee cellular cementum, 142–5
Camargue cattle, 111–12
camels, 87
caribou, 30
caries
effects on cementum, 56
caries therapy
effects on cementum, 58
cave bears, 288, 301
cave hyaenas, 288
carnivore cementum studies, 289
cementum analysis, 296–9

cave hyaenas (cont.)
land-use strategy, 300
presence in southern Belgium (Late Pleistocene), 301
tooth samples, 294
cellular cementum, 50–1
cementocytes, 51
chimpanzee cellular cementum elemental distribution, 138–51
formation of, 47–50
cellular intrinsic fiber cementum (CIFC). *See* cellular cementum
cellular mixed stratified cementum (CMSC), 51
cementoblastoma, 58
cementoblasts, 47, 49–50, 54
BSP as marker for, 74
cémentochronologie, 3
cementochronology, 83–4
accounting for individual variations in the aging process, 166
comparison with markers of biological aging, 10–11
future of, 162–5
hurdles preventing reliable use of cementum variations, 165–6
influences on cementum mineralization, 163
influences on the chemical composition of cementum increments, 163–4
methodological issues in studies of life-history events, 165
need for a standardized protocol, 38–9
optimizing protocol variables, 198
optimizing sample preparation and imaging protocols, 189
origin of the term, 3
preparation protocols specific to cementum studies, 195–8
virtual cementochronology, 164–5
See also tooth cementum annulations (TCA) method
cementochronology key advances, 379
applications, 385–9
automated counting of increments, 384
cementum biology, 379–80
dealing with concerns about cementochronology, 389–90
dietary hypothesis, 381
hypotheses on the influences on cementum growth, 381–2
identification of life-history events in cementum, 380
life span studies, 386
mammalian evolution studies, 386
noninvasive virtual 3D cementochronology, 384
optimizing thin-section production, 383
population fertility studies, 385–6
protocols, 382–5
search for the ideal skeletal age indicator, 386–9
season-of-death validation studies, 383
seasonality and mobility patterns, 385
seasonality hypothesis, 381–2
stress markers in cementum, 383–4
synchrotron X-ray studies, 384
understanding cementum growth variations, 383–4
Cementochronology Research Program, 389
cementocytes, 47, 51
cementogenesis, 46–9
acellular cementum, 47, 50
cellular cementum, 47–50
cementoblasts, 47, 49–50
cementocytes, 47
collagen fibers, 47
potential insights from mouse models, 75–7
regulation by pyrophosphate, 70–3, 76
role of ECM proteins, 73–5
role of Hertwig's epithelial root sheath (HERS), 47
cemento-osseous dysplasia, 58
cemento-ossifying fibroma, 58
cementum
circannual rhythms, 6
circannual rhythms studies, 9–10
incremental growth patterns, 9–10
insights into the origin and evolution of, 77
mechanisms of cementum banding, 75–6
terms relating to, 2–3
See also acellular cementum; cellular cementum
cementum annulation
wildlife and zoo studies, 29–30
cementum biology, 379–80
aspects of, 46
cementum formation (cementogenesis), 46–9
clinical and environmental considerations in TCA analysis, 54–9
comparison with bone, dentin, and enamel, 54
composition of cementum, 53–4
types of cementum, 50–3
cementum–dentin junction
identifying, 116–18
cementum deposition
hypercementosis, 99–104
cementum deposition modulators
antemortem loss of antagonistic teeth, 99
apical periodontitis, 98
dentoalveolar compensations, 95–7
occlusal trauma, 98
pathological factors, 97–9
pathological tooth displacement, 98
periodontal disease, 97–8
physiological factors, 94–7
root anatomy, 94–6
root caries, 98–9
tooth eruption and function, 94–5

cementum formation. *See* cementogenesis
cementum mineralization front
  identifying, 116–18
cementum types, 50–3
  acellular afibrillar cementum (AAC), 51
  acellular cementum, 50–1
  cellular cementum, 50–1
  cellular mixed stratified cementum (CMSC), 51
  coronal cementum, 53
  reparative cementum, 51
Childe, V. Gordon, 322
chimpanzee cellular cementum study
  barium distribution in cementum, 140
  calcium concentrations, 142–5
  calcium distribution in cementum, 139–40
  data acquisition, 142
  experimental setup, 141–2
  incremental elemental distribution, 138–9
  mineral concentrations and incremental lines, 148–51
  phosphorus concentrations, 142–5
  phosphorus distribution in cementum, 139–40
  samples, 141
  second-order incremental markings, 147–8
  strontium concentrations, 145–6
  strontium distribution in cementum, 140
  synchrotron X-ray fluorescence, 141
  trace elements in cementum, 139–40
  zinc concentrations, 146–7
  zinc distribution in bone and dental tissues, 140
chimpanzees, 97
chondrocalcinosis (CCAL2), 72
chronic sclerosing osteomyelitis, 102
chronobiology, 1, 3, 10
  biological clocks, 387
  cycles of life, 3–4
  origin of the field, 3
chronotypes, 4
circadian clocks, 3
circadian rhythms, 4
  bone deposition and mineralization, 6
  dentin, 6
  mechanisms for, 5
  relationship to circannual rhythms, 6
  teeth, 6
  tooth enamel, 6
circannual clocks, 3
circannual rhythms, 4
  adaptive benefits of, 6–7
  cementum, 6
  chronotypes, 4
  clock-shop model, 5–6
  environmentally evoked rhythms, 5
  environmentally synchronized rhythms, 5
  epigenetic regulation, 5
  evolutionary origins, 5
  mechanisms responsible for, 4–7
  relationship to circadian rhythms, 6
  seasonal (circannual) progressive rhythms, 4
  teeth, 6
  trans-generational annual rhythms, 4
  types of, 4–5
circannual rhythms validation studies, 7–10
  amphibians, 7
  bone, 7–8
  cementum incremental growth patterns, 9–10
  fish, 7
  humans, 8
  mammals, 8
  methods of demonstrating hard tissue seasonal growth in animals, 7
  Nile crocodiles, 7–8
  sclerochronology, 7
  sharks, 8
  skeletochronology, 7–8
  teeth, 9–10
  ungulates, 8
circaseptan rhythms, 4
clock genes
  ARNTL gene, 86
clock-shop model, 5–6, 10
collagen fibers
  role in cementogenesis, 47
combined age estimate method, 338
Complex Method for age-at-death estimation, 366
Contemporary Demographic Transition, 331
coronal cementum, 53
coyotes, 30
craniometaphyseal dysplasia (CMD), 72
crocodiles, 86–7
Cuvier, Georges, 25

deciduous teeth. *See* human deciduous teeth TCA study
demographic regimes
  evolution of, 322–3
  Neolithic Revolution hypothesis, 322
demography
  pre-farming fisher-gatherer population in Brazil, 322–33
dental cementum increment analysis (DCIA), 3, 50
dental disease and trauma
  effects on cementum, 56–58
dental eruption charts, 216
dental therapies
  effects on cementum, 58
dentin
  circadian rhythms, 6
  cyclic growth, 6
  incremental growth patterns, 6
  properties compared with cementum, enamel, and bone, 54
  von Ebner's lines, 9
dentin matrix protein 1 (DMP1), 47, 51, 54, 73

dentin phosphoprotein (DPP), 47, 73
dentin sialoprotein (DSP), 47, 73
dentoalveolar compensations
  modulation of cementum deposition, 95–7
diagenesis
  effects on tooth cementum, 37
dietary hypothesis, 381
dinosaurs, 7, 8, 10, 83
disability, bioarcheology of
  osteobiography of a Middle Woodland woman, 306–16
domestic cat, 87
drugs
  effects on cementum, 59
Dupont, Édouard, 289, 290–1

ectonucleotide pyrophosphatase phosphodiesterase I (ENPP1), 72–3
ectopic calcification, 70, 72
elephant seals, 158
elephants, 25
elk, 30
enamel
  circadian rhythms, 6
  incremental growth patterns, 6
  properties compared with cementum, dentin, and bone, 54
enamel dysplasia with hamartomatous atypical follicular hyperplasia, 102
enamel renal syndrome, 102
endodontic therapy
  effects on cementum, 58
ENPP1 gene, 90
ENPP1 gene mutations, 72–3, 76
ENPP1 mutant or knock-out mice, 72–3
environmentally evoked circannual rhythms, 5
environmentally synchronized circannual rhythms, 5
European lynxes, 158
Eustachio, Bartolomeo, 23
evolution
  adaptive benefits of circannual rhythms, 6–7
  insights into the origin of cementum, 77
  mammalian evolution studies, 386
  origins of circannual rhythms, 5
evolutionary genetics of cementum
  ALPL candidate gene, 84–5
  ARNTL candidate gene, 86
  BMP-2 candidate gene, 85
  BMP-7 candidate gene, 85
  branch-specific selection patterns, 86–7
  candidate gene study methods and results, 86–91
  candidate genes, 84–6
  comparative genetic analysis approach, 84
  evidence for purifying selection, 86
  evolution of genes associated with cementum deposition, 89–90
  influence of diet type, 87–8
  influence of life span, 88–9
  influence of tooth count and radicularity, 88–91
  lineage-specific selection pressures, 87
  selection pressures on the ALPL gene, 85
  selection pressures on the ARNTL gene, 86
  selection pressures on the BMP-2 gene, 85
  selection pressures on the BMP-7 gene, 85
evolutionary history of cementum
  thecodonty, 83
external root resorption, 98
extracellular matrix (ECM) proteins
  role in cementogenesis, 73–5, 76–7
  SIBLING family of proteins, 73–5

fetuin-A (AHSG), 70
fibroblast growth factor 23 (FGF23), 68
fibro-osseous lesions of the jaw, 58
fish, 9
  otolometry, 7
  scalimetry, 7
fisher-gatherers
  pre-farming population demography, 322–33
flying foxes, 86
forensic anthropology, 3
fossil hominin tooth study
  diagenetic and taphonomic effects on the cementum, 148–50
  future directions in fossil tooth study, 151
  sample, 141
  synchrotron X-ray study, 141
fossils, 10, 29
  toothed fossil birds, 10
foxes, 157
Fränkel, Meyer, 25

Galen, 22–3
Gardner syndrome, 102
gazelle, 29
gene editing
  gene knock-in, 67
  gene knock-out, 67
  mouse models, 67
  transgenic expression, 67
generalized arterial calcification in infancy (GACI), 72
genetic disorders
  ANK gene mutations, 72–3
  ENPP1 gene mutations, 72–3
  hypophosphatasia (HPP), 72
  X-linked hypophosphatemia, 70
genetic model organisms
  mouse genetic models, 65–7
genetic mutations
  effect on cementum formation and stability, 56
gharials, 86–7
gingivitis
  during pregnancy, 155–6

goiter
association with hypercementosis, 100
Gompertz-Makeham hazard model, 351, 352, 354, 356–7
gorillas, 140
greater kudu, 29
growth layer groups (GLG), 2
growth layer of the first order, 2
growth rest lines, 2
growth zones, 2

Hadza people of Tanzania, 329
Hannum clock, 387
Hertwig's epithelial root sheath (HERS), 47
hibernation, 9
history of cementum discovery, 2–3
history of cementum studies, 21–2
correlation of cementum thickness with age in humans, 28–9
development of cementum analysis protocol, 30–6
discovery and early characterizations, 22–7
early twentieth century, 28–30
late twentieth and twenty-first century, 30–6
ongoing methodological issues, 36–7
twenty-first century developments, 36–7
validation studies for age-at-death estimation, 31–6
wildlife and zoo studies of cementum annulation, 29–30
Hiwi people of Venezuela, 329
hominids
life span and evolution studies, 386
hominin strategies in southern Belgium (Late Pleistocene)
approach to accessing seasonal information, 301–2
carnivore cementum studies, 289
cave hyaena cementum analysis, 296–9
cave hyaena land-use strategy, 300
cave hyaena tooth samples, 294
Caverne Marie-Jeanne site, 292
implications for competition among top predators, 300–1
indications of seasonal occupation of sites, 299–300
materials, 290–4
methods, 294–5
possible seasonal subsistence strategy, 299–300
potential competition between top predators, 288–9
prey selection and mobility of predators, 294–6
prey-species seasonality at Caverne Marie-Jeanne, 295
prey-species seasonality at Tiène Des Maulins, 295
prey-species seasonality at Trou Magrite, 294–5
results, 294–9
sampling strategy and analyzed material, 292–4
site description and research history, 290–2
Tiène des Maulins site, 291
Trou Magrite site, 290–1
hormonal physiology
animal studies of cementum growth effects, 157–9
effects on oral health and cementum growth, 155–7
human studies of cementum growth effects, 159–62
horses, 25, 379
Horvath clock, 387
human deciduous teeth TCA study
directions for future study, 223
issues with age-at-extraction estimation, 223–4
methodological challenges, 215
methods, 219
results, 219–20
review of literature on age-at-death estimation, 216
sampling limitations for deciduous teeth, 216–17
sources of error, 220–3
study sample, 217–18
humans
archeological reference collection (Middle Ages), 111–12
bone remodeling and age estimation, 8
circannual growth patterns, 8
correlation of cementum thickness with age, 28–9
effects of life-history events on cementum growth, 159–62
history of the use of cementum for age estimation, 3
lamellar bone growth rates, 8
strontium concentrations in dental tissues, 140
hunter-gatherers
demography of contemporary groups, 329–30
hydroxyapatite, 53, 54, 73, 139–40
phosphase metabolism and, 67–8
pyrophosphate regulation, 70–3, 76
hypercementosis, 94, 95, 99–104
association with acromegaly, 100–1
association with Paget's disease, 100
association with thyroid goiter, 100
cementum ridges (spike-like projections), 103
diffuse form, 99–103
in past populations, 102–4
nodular forms (cementicles), 103–4
potential indicator of past population health, 104–5
hypophosphatasia (HPP), 72, 84–5

IBSP gene, 53
IBSP gene polymorphisms, 75
IBSP–/– mice, 75

ichthyosaurs, 10
identities in the past
  role of osteobiography, 306–7
identity
  age identities, 308
idiopathic hypoparathyroidism, 102
incremental growth layers, 2
insectivores, 30
interdisciplinary research, 1
interobserver reliability
  ungulate teeth thin sections, 201–13
intradian rhythms, 3

Juvenility Index, 330

kidney-parathyroid-bone axis, 68
!Kung people of Botswana-Namibia, 329, 330
Kutchin Athapaskan people, 330

Lamedin dentin translucence method, 38
life-histories
  osteobiography of a Middle Woodland woman, 306–16
life-history events
  animal studies of cementum growth effects, 157–9
  effects of pregnancy on cementum growth, 155–7
  hormonal effects on cementum growth, 155–7
  human studies of effects on cementum growth, 159–62
  hurdles preventing reliable use of cementum variations, 165–6
  identifying in dental cementum, 155–66, 380
  identifying parturition lines in acellular cementum, 234–46
  individual variations in the aging process, 166
  influences on cementum mineralization, 163
  influences on the chemical composition of cementum increments, 163–4
  methodological issues in cementum studies, 165
ligne d'arrêt de croissance, 2
London Atlas of Human Tooth Development, 216
lunar rhythms, 4

macaques, 8, 9, 30, 50, 96, 140, 148, 263, 270
Malpighi, Marcello, 23
mammals, 7
  circannual growth patterns, 8
  mammalian evolution studies, 386
  marine mammals, 30
marmosets, 30
matrix extracellular phosphoglycoprotein (MEPE), 73
matrix gla protein (MGP), 70
medications
  effects on cementum, 59
methyl methacrylate (MMA), 185
mink, 9
monkeys, 8
moose, 29, 30
Morganucodon, 260, 262, 270
morphological age estimation (MAE) methods, 366
mortality profile. *See* age-at-death distribution
mosasaurs, 10, 83
mouse genetic models, 65–7
  ALPL knock-out mice, 72
  ANK mutant or knock-out mice, 72–3
  ENPP1 mutant or knock-out mice, 72–3
  gene-editing techniques, 67
  HYP mouse, 68–70
  IBSP–/– mice, 74–5
  implications for vitamin D-related rickets, 76
  mouse dentition, 67
  potential insights from, 75–7
mouse lemur, 8
mule deer, 29
multidien rhythms, 4

Nabataean age-related mortality
  age-bias problem, 352–3
  challenges in deriving age-related mortality, 351–3
  challenges of reconstructing a population mortality profile, 353–4
  confounding effect of a growing or shrinking population, 351–2
  Gompertz-Makeham hazard model, 351, 352, 354
  Gompertz-Makeham hazard model applied to the sample data, 356–7
  history of Petra and the Nabataean kingdom, 353–4
  implications of the age-related mortality profile, 360–1
  interpretation of the pattern of age-related mortality, 254–5
  materials and methods, 354–7
  Petra North Ridge burials, Jordan, 351–2
  problem of small sample size, 352
  reconstruction of the age-at-death distribution, 357–9
  results, 357–9
  sample selection, 354–5
  value of cementochronology for individual age-at-death estimates, 360–1
Neanderthal spatial organization
  anticipation of prey behavior and distribution fluctuations, 275–6
  bison hunting in the Discoidal Denticulate Mousterian, 276–9
  bison kill and butchery sites, 279–80
  cementum analysis of samples, 280–1
  Discoidal Denticulate faunal assemblages, 279–80

Discoidal Denticulate Mousterian fauna, 276–9
hunting seasonality, 275
influence of prey behavior, 283–4
materials and methods, 280–1
mobility strategies in the Late Middle Palaeolithic, 276–9
patterns of occupation and mobility, 282–4
Quina reindeer assemblages, 279
reindeer butchery sites, 279
reindeer hunting in the Quina Mousterian, 276
results of cementum analysis, 281
seasonal use of specific sites, 282–4
southwest France context, 275–6
structure related to the predation system, 283–4
task-specific locations, 276, 282–4

Neanderthals, 103
hominin strategies in southern Belgium (Late Pleistocene), 288–302

Neolithic Revolution hypothesis, 322

Neolithic studies, 29

Nile crocodiles
annual growth pattern, 7–8

nomenclature
terms relating to cementum, 2–3

nondestructive imaging of TCAs
current limitations, 253–4
data collection, 250–1
future improvements in scanning and fine-tuning reconstruction, 254
methodological advantages of virtual histology, 250–3
nondestructive methods, 103–4
optical coherence tomography (OCT), 249
potential of phase-contrast synchrotron X-ray microtomography, 254–5
prior optimization for choosing the ROI to scan, 254–5
propagation phase-contrast synchrotron X-ray microtomography, 249
sample, 250–1
Terahertz imaging, 249
validation by combining with thin sectioning, 253

noninvasive 3D imaging of cementum
advantages of PPSRCT, 258–65
current limitations of PPSRCT imaging, 265–7
PPCI through SR CT (PPSRCT), 258
quantitative approaches to synchrotron X-ray imaging, 269
time line and guide to a PPSRCT cementum imaging experiment, 267–9

noninvasive virtual 3D cementochronology, 384

Nunamiut people, 330

occlusal trauma
influence on cementum deposition, 98

odontocete age estimation, 2

odontochronology, 9

odontogenic tumors, 56–58

optical coherence tomography (OCT), 249

optical microscopy illumination comparison, 190
discussion of illumination techniques, 195–7
results, 194
sample preparation, 192
samples, 191–2

oral health
effects of pregnancy on cementum growth, 155–7

orang-utans, 140

orthodontic therapy, 56
effects on cementum, 58

osteobiography of a Middle Woodland woman
achondroplasia and pregnancy, 313–14
age and identity of EZ 3-7-1, 314–16
age and pregnancy, 313–14
age identities, 308
archeological context, 308
biological age (age-at-death) estimation, 307–8
constructing the osteobiography of EZ 3-7-1, 311–14
evidence of a combined skeletal dysplasia (achondroplasia and Leri-Weill dyschondrosteosis), 306, 308–9
excavation of EZ 3-7-1 (female adult) and EZ 3-7-2 (fetal remains), 306
identity and osteobiographies, 306–7
life expectancy in the Middle Woodland period, 312–13
mortality and achondroplasia, 311–12
osteological evaluation, 308–9
paleodemography of the Middle Woodland period, 312–13
revised age-at-death estimation, 309–11

osteocalcin (OCN), 47, 49

osteological paradox, 166

osteopontin (OPN), 47, 49, 53, 54, 70, 73

osteoporosis therapy
risk of osteonecrosis of the jaw, 59

otolometry, 7

otters, 30

Owen, Richard, 25

Paget's disease
association with hypercementosis, 100

paleodemography, 323

paleoecology, 386

parametric hazard models, 388

Paranthropus boisei fossil tooth
diagenetic and taphonomic effects on the cementum, 148–50
study sample, 141
synchrotron X-ray study, 141

parathyroid hormone (PTH), 68

parturition lines in acellular cementum
chemical signal of pregnancy, 243–5
effects of life-history events, 234–5

parturition lines in acellular cementum (cont.)
environmental scanning electron microscopy, 237
experimental design, 235
grayscale profile analysis by Fiji software, 236
histological preparation of samples, 235–6
methodological approach, 243
physical nature of broad annulations, 245–6
protocol for identification, 246
Raman microspectrometry and imaging analysis, 236–7
results, 237–44
sample collection, 235
pathological tooth displacement
influence on cementum deposition, 98
Pendred syndrome, 102
penguins, 87
periodontal disease
effects on cementum, 56
influence on cementum deposition, 97–8
periodontal ligament (PDL), 51
periodontal treatment, 56
effects on cementum, 58
periodontitis
during pregnancy, 155–6
Petra, Jordan, North Ridge burials. *See* Nabataean age-related mortality
PHEX gene mutations, 68
PHEX gene mutations (mouse), 68–70
phosphate metabolism, 67–70, 76
phosphorus
concentrations in chimpanzee cellular cementum, 142–5
pigs
multidien (5-day) rhythms, 6
pituitary gland, 5
polar bears, 158
polyphyodonty, 87
population fertility studies, 385–6
positive selection, 85, 86
PPCI (propagation-based phase-contrast imaging) through SR CT (synchrotron-based computed tomography) (PPSRCT), 258
pre-farming population demography, 322–3
adult age estimation using cementochronology, 326–7
age-at-death estimation using cementochronology, 323–4
Brazilian *sambaquis*, 324–6
Cabeçuda skeletal sample, 325–6
demography of contemporary hunter-gatherer groups, 329–30
interpreting the age-at-death distribution, 328–30
limitations of the Cabeçuda data, 332–3
material and method, 324–7
metabolic load hypothesis, 332
models of preindustrial demography, 329–30
potential influences on the demographic distribution, 332–3
proxy indicator of fertility ($_{15}P_5$ ratio), 330–1
results, 327–8
total fertility rate (TFR), 331–2
pregnancy
effects on oral health and cementum growth, 155–7
gingivitis related to, 155–6
identifying parturition lines in acellular cementum, 234–46
osteobiography of a Middle Woodland woman, 306–16
periodontitis related to, 155–6
tooth loosening related to, 155–6
primary cementum. *See* acellular cementum
primates, 30
probabilistic method, 342, 388
progressive ankylosis protein (ANK), 72–3
propagation-based phase-contrast imaging (PPCI), 258
propagation phase-contrast synchrotron X-ray microtomography, 249
proteoglycans, 47
protocols
key advances in, 382–5
standardized protocol in cementochronology, 38–9
puberty
evidence of onset in acellular cementum, 245
pulpal necrosis, 56
purifying selection, 85, 86
evidence in cementum candidate genes, 86
Purkinje, Jan, 25, 46
pycnodysostosis, 102
pyrophosphate regulation of cementogenesis, 70–3, 76

rabbits, 87
rats, 8
red deer, 111–12
red foxes, 30
regenerative cementum. *See* reparative cementum
region of interest (ROI) selection
age-at-death estimations from different observers, 212
criteria for inclusion, 202–3
importance of observer training and experience, 212–13
methodological issues, 201
optimal ROI selection by applying the criteria, 212
sample set, 203
season of death estimations from different observers, 212
study objective, 202–3
study results, 204–12
testing an optimal ROI selection, 203–4

reindeer, 111–12, 276, 279, 385
renal osteodystrophy, 102
reparative cementum, 51, 58
reptiles, 7, 10
Retzius, Anders, 25, 46
rickets
phosphate metabolism and, 76
vitamin D-related rickets, 76
X-linked hypophosphatemia, 70
Ringelmann, Carl Joseph von, 25
rodents, 30
root caries
influence on cementum deposition, 98–9
root resorption, 58
effects on cementum, 56
external, 98
Rostock Paleodemography Workshops, 36
RSK2 gene, 90

saliva flow
influence on oral health, 156
Saul, Frank, 307
scalimetry, 7
sclerochronology, 7
sclerostin (SOST), 51
sea otters, 158
seals, 4, 29, 86, 87, 158, 159
season at time of death
identification of US POW/MIA service members, 226–32
mobility patterns and, 385
validation studies, 383
seasonal (circannual) progressive rhythms, 4
seasonal affective disorder, 4
seasonality hypothesis, 381–2
secondary cementum. *See* cellular cementum
sharks
circannual growth patterns, 8
Sharpey's fibers, 47, 49, 51, 157
sheep, 8
Siler mortality model, 360
skeletochronology, 7–8
small integrin-binding ligand N-linked glycoprotein (SIBLING) family of proteins, 53, 54, 73–5
SOST gene mutations, 51
SPP1 gene, 54
squirrels, 30
standardized protocol in cementochronology, 38–9
stressors
effects on cementum growth, 380
stria of Retzius, 9
strontium
concentrations in chimpanzee cellular cementum, 145–6
suprachiasmatic nuclei, 5
synchrotron X-ray studies
acellular cementum increments composition, 110–35
chimpanzee cellular cementum elemental distribution, 138–51
key advances in cementochronology, 384
nondestructive imaging of TCAs, 249–55
noninvasive 3D imaging of cementum, 258–69
synchrotron-based computed tomography (SR CT), 258
systemic lupus erythematosus, 102

taphonomy
effects on tooth cementum, 37
teeth
circadian rhythms, 6
circannual rhythms, 6, 9–10
Tenon, Jacques-René, 25
Terahertz imaging, 249
thecodonty, 83
thin-section preparation
diversity of approaches for nonhuman teeth, 173
embedding materials comparison, 190, 191–3, 195, 197
epoxy resin embedding material, 190
issues with ungulate teeth, 201–13
methyl methacrylate (MMA) embedding material, 190
optimizing production, 383
optimizing protocol variables, 198
planes of sectioning comparison, 191–2, 193–4, 195–6, 197–8
thin-section preparation protocol
animal and human protocol proposal, 186–7
cutting quality, 177–81
according to the cutting plane (height), 181
according to the cutting plane (length), 181
according to the cutting settings, 180
according to the diameter of the flanges used, 180–1
according to the model of the cutting disc used, 180
according to the resin and catalyst dosages, 179
according to the resin used, 179
according to the sample position, 180
variability with fixed parameters, 177–9
finishing step, 184
different methods of finishing, 184
use or not of a coverslip, 184
four main steps, 173
gluing quality, 181–4
according to pressure, 184
according to temperature, 182
according to the surface condition of the slide and the specimen, 182
measures of, 182–4
intraobserver errors, 174–5
operations for the experimental designs

thin-section preparation protocol (cont.)
optimization study, 173–4
resin consolidation quality, 175–7
according to flow height, 176
according to flow velocity, 176
according to mixing mode, 176
according to the vacuum cycle, 177
inclusion quality with or without vacuum, 177
sections with embedded objects, 185
air bubbles, 185
methyl methacrylate (MMA) embedding, 185
polymers used for embedding, 185
resin embedding, 185
time-of-flight secondary ion mass spectrometry, 161
tissue nonspecific alkaline phosphatase (TNAP), 49–50, 72, 84
tooth cementum annulations (TCA) method, 3, 22, 50
clinical and environmental considerations, 54–9
effects of caries on cementum, 56
effects of caries therapy on cementum, 58
effects of dental disease and trauma, 56–58
effects of dental therapies on cementum, 58
effects of drugs on cementum, 59
effects of endodontic therapy on cementum, 58
effects of genetic mutations, 56
effects of orthodontic therapy on cementum, 58
effects of periodontal disease on cementum, 56
effects of periodontal treatment on cementum, 58
effects of root resorption on cementum, 56
effects of tumoral lesions on cementum, 56–58
human deciduous teeth, 215–24
identification of US POW/MIA service members, 226–32
need for a standardized protocol, 38–9
nondestructive imaging using synchrotron X-ray microtomography, 249–55
ongoing methodological issues, 36–7
protocol development and validation studies, 30–6
See also cementochronology
tooth decay. *See* caries
tooth loosening
related to pregnancy, 155–6
tooth loss
effects of loss of antagonistic teeth, 99
tooth whitening agents, 56
trans-generational annual rhythms, 4
transition analysis, 338, 388
trauma
effects on cementum, 58
tumoral lesions
effects on cementum, 56–58
Turkana pastoralists, 330

ungulates, 29–30
circannual growth patterns, 8
problem of thin-section preparation and interpretation, 201–13
US military POW/MIA recovery missions
age and season-of-death estimation, 226–7
age estimation by TCA, 231
effects of dental disease and treatments on age estimations, 232
identification of service members, 226–7
identifying season at time of death, 231–2
potential value of TCA analysis, 232
protocol for TCA analysis, 230–1
results of TCA age and season-of-extraction study, 228–31
study sample of teeth from active service members, 227–8

Van Buchem disease, 51
Van Leeuwenhoek, Antoni, 23
Vesalius, Andreas, 23
virtual cementochronology, 164–5
vitamin D, 68, 76
vitamin D-related rickets, 76
von Ebner's lines, 9

walruses, 158
waterbuck, 29
whales, 127, 134, 140, 147
white-tailed deer, 29

X-linked hypophosphatemia, 70

zinc
concentrations in chimpanzee cellular cementum, 146–7
distribution in bone and dental tissues, 140
zooarchaeology, 83