

Bi4041 Paleopathology

**Infections & deficiencies:
variability in health**

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www.ephe.psl.eu

MUNI

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The slide features a dark red and black geometric background with a white diagonal stripe. A blue box with the text 'MUNI' is in the top right corner. The title is in large white font, and the author's name and affiliation are in smaller white font below it. The website URL is in the bottom left. The logos for 'École Pratique des Hautes Études' and 'PSL' are in the bottom right.

Bi4041 Paleopathology

infections & deficiencies

Variability in health:
Pathocenosis &
epidemiologic transition

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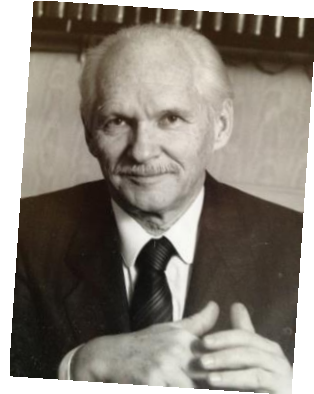
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The slide features a red and black geometric background with a white diagonal stripe. The title 'infections & deficiencies' is in large white font, enclosed in a white-bordered box. Below it, the subtitle 'Variability in health: Pathocenosis & epidemiologic transition' is also in white font. The course code 'Bi4041 Paleopathology' is in the top left. The website URL is in the bottom left. The logos for 'École Pratique des Hautes Études' and 'PSL' are in the bottom right.

The concept of pathocenosis (1)

“The pathological states within a given population, in time and space, form a set that we call **pathocenosis**”

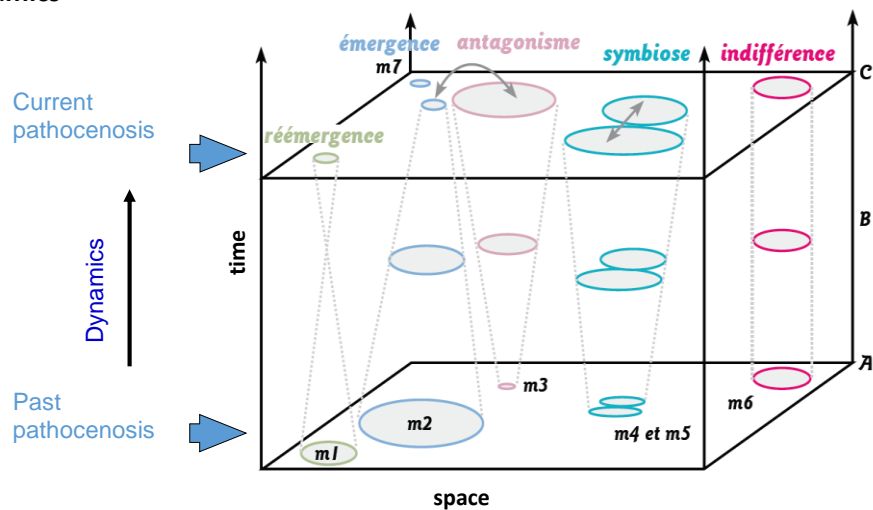
- Based on the definition of **biocenosis**:
 - Set of pathogens and diseases coexisting in a **given time & space**
 - disappearance or emergence of one pathogen: change in the pathocenosis
- Interdependence of diseases: « **ecological balance** » in their frequency and distribution
- Balance disruption: disease **disappearance or emergence**



Mirko Grmek (1924-2000)
French-croatian physician and paleopathologist

The concept of pathocenosis (2)

“pathocenosis dynamics”

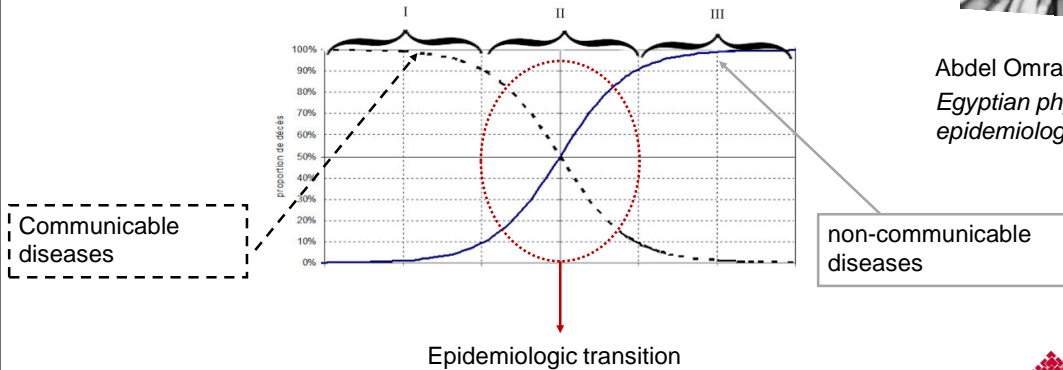


The concept of epidemiologic transition (1)

- **Mortality:** fundamental factor in population dynamics
- **Infection pandemics:** gradually replaced by degenerative & *civilisation* diseases
- the most important changes for children and young women
- closely associated with the **demographic and socioeconomic transitions**



Abdel Omran (1925-1999)
Egyptian physician and epidemiologist



03/49 Omran 1971, *The Milbank Memorial Fund Quarterly*

The concept of epidemiologic transition (2)

Health status of a population depends on:

- Mortality: death frequency (dying from)
- Morbidity: diseases frequency (dying with)

Indicators of morbidity:

- Prevalence of specific diseases
Dental paleopathology, infectious, degenerative & metabolic, trauma, etc.
- Prevalence of non specific stress indicators
Harris lines, LEH, cribra cranii, orbitalia, humeralis, femoralis, porosities, etc.

Indicators	Health status -	Health status +
Life expectancy at birth	Low	High
Infant mortality rate	High	Low
dental pathological signs	Frequent	Moderate
Non specific morbidity	Frequent & multiple	Rare
Highest specific morbidity	Infectious	Degenerative & metabolic

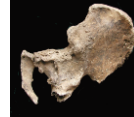
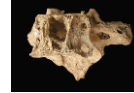
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The concept of epidemiologic transition (3)

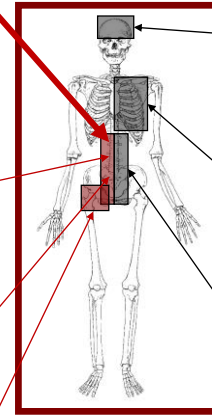
▪ **Prevalence** : total number of cases of a disease in a specific population for a specific time

▪ In paleoepidemiology: **$P = n/N$**
 « **n** » **number of cases** for the studied disease related to the paleopathological diagnosis
 → Better inclusion of the disease (pathognomonic and minor forms)

« **N** » **number of individuals** in the archeological pop.
 → Take into account the skeletons **preservation**
 $P = n/N - a$ (*a*: non observable parts)



Bone tuberculosis
 Hungary, 8th-18th c., N = 1294



$n_0/N = 0.2\%$

$N_{0+...+x}/N = 3.8\%$

05/49

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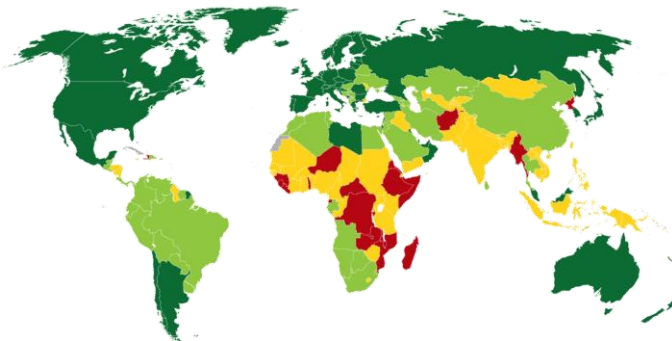
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The concept of epidemiologic transition (4)

Causes of death in 2010 (2015)

	CD	NCD
Low-income countries	69% (53%)	21% (37%)
middle-income countries	28%	50%
High-income countries	15% (4%)	77% (88%)



 High-income countries
 Upper-middle-income countries
 Lower-middle-income countries
 Low-income countries

06/49 WHO, 2010 ; WHO, 2018

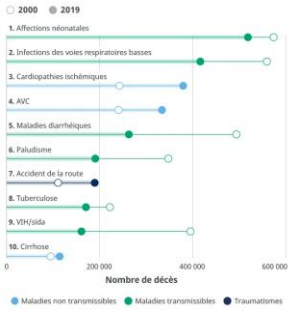
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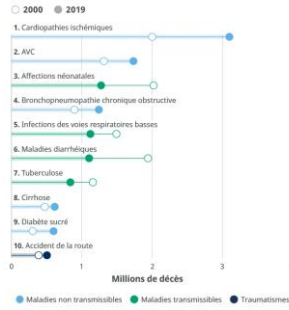
The concept of epidemiologic transition (5)

Top 10 causes of death in 2000 & 2019

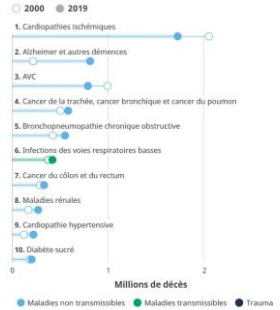
Les principales causes de mortalité dans les pays à faible revenu



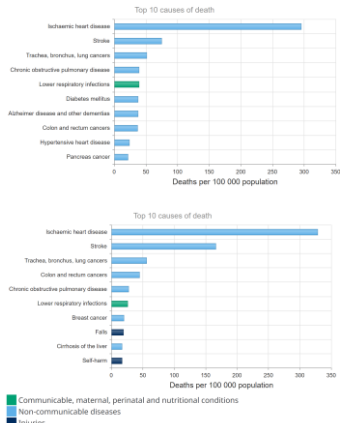
Les principales causes de mortalité dans les pays à revenu intermédiaire de la tranche inférieure



Les principales causes de mortalité dans les pays à revenu élevé



Top 10 causes of death in 2000 & 2019 in Česká republika



07/49 WHO, 2020; <https://www.who.int/data/gho/data/themes/mortality-and-global-health-estimates/ghle-leading-causes-of-death>



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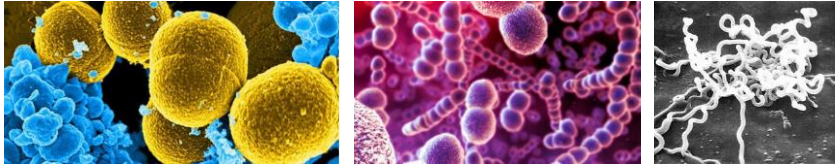
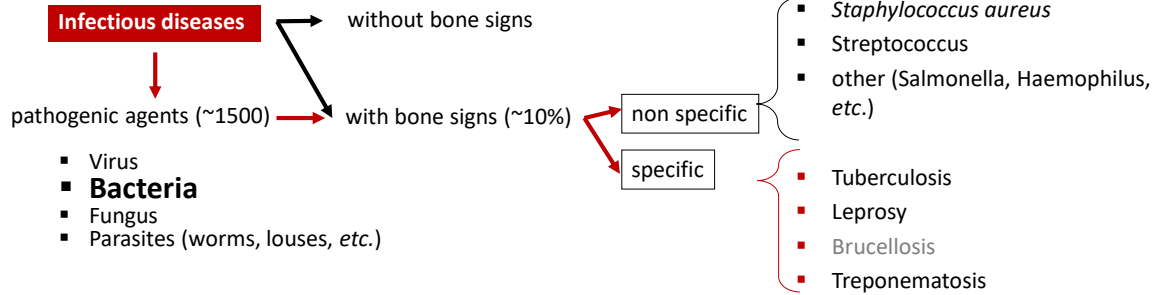
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Infections

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Infectious diseases (1)



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Infectious diseases (2)

- **bone topography:**
 - Myelitis
 - Osteitis
 - Periostitis
- **Ways of infection:**
 - Hematogenous
 - Direct
- **evolution:**
 - Acute / chronic
 - Fusion / ankylosis
- **anatomy-clinic form:**
 - Osteomyelitis
 - Osteoperiostitis
 - Arthritis / osteoarthritis
 - Spondylodiscitis
 - Sacroiliitis



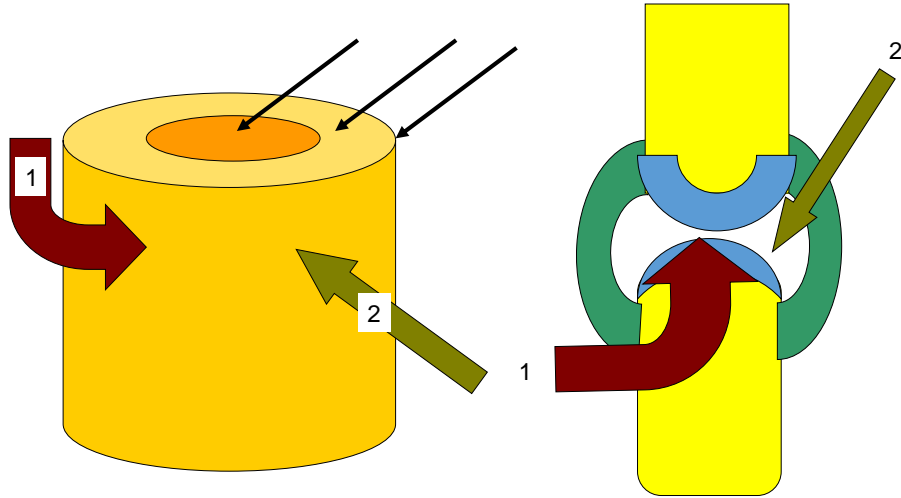
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Infectious diseases (3)

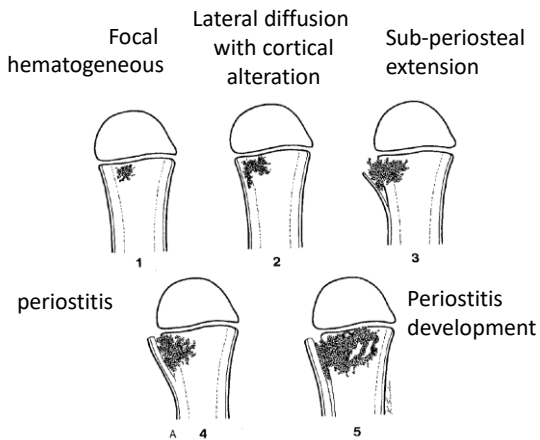


1 – Bloodstream infection / sepsis

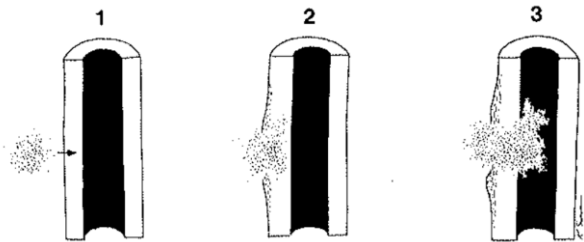
2- direct inoculation (from outside or by proximity)

Infectious diseases (4)

osteomyelitis



osteoperiostitis



Infectious diseases (5)

osteomyelitis



12/49 Resnick 2002

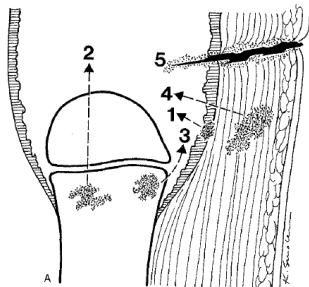
Spina ventosa



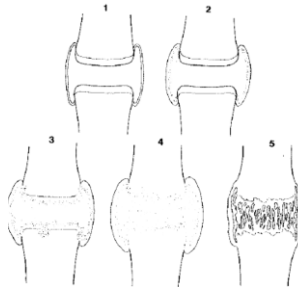
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Infectious diseases (6)

articular infection= osteoarthritis



- 1- synovial hematogenous
- 2/3 - metaphyseal (*osteomyelitis*)
- 4 - contiguity
- 5- direct inoculation



- 1 - normal
- 2 - oedema
- 3/4 - cartilage destruction
- 5 - articular fusion

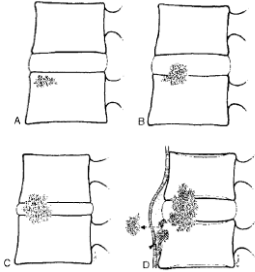


13/49 Resnick 2002

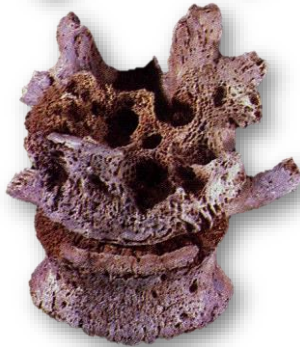
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Infectious diseases (7)

spondylodiscitis



- A - Anterior hematogenous infection
- B - Disc contamination
- C - contiguous vertebra contamination
- D - anterior extension (vertebral body, ligament, prevertebral space)



sacroiliitis



- Hematogenous, contiguity, direct inoculation



14/49 Resnick 2002

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Infectious diseases (8)

virus & fungus



Viral infection

Smallpox

Osteomyelitis variolosa



Fungal infection:
Madurella mycetomatis
Actinomycosis

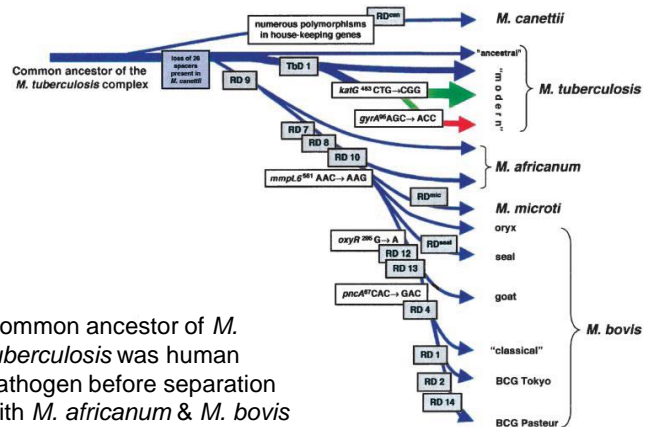


15/49 Lyautey et al. 2013, GPLF; Darton et al. 2013, Int. J. Paleopathol.

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Tuberculosis (1)

Mycobacterium tuberculosis



Common ancestor of *M. tuberculosis* was human pathogen before separation with *M. africanum* & *M. bovis*

→ Predate domestication
(before the Neolithic)

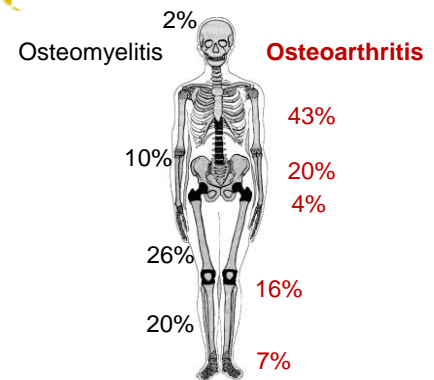
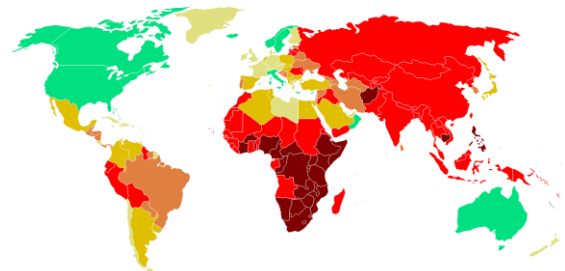
Tuberculosis (2)

- Highly communicable

The 10% rule :

- Over 100% of exposition
- 10 % of primo-infection
- 10 % of visceral tuberculosis (1%)
- 10 % osteoarticular tuberculosis (0,1%)

- spine (Pott's disease)
- Hip, knee, wrist, ankle



Tuberculosis (3)

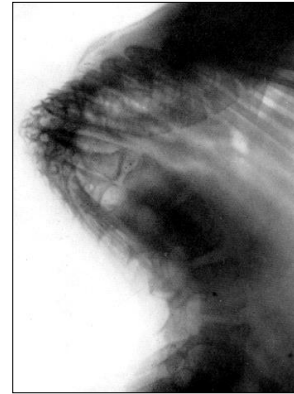
Pott's disease



Guadeloupe, 18th c.



Hungary, 18th c.



- 1 to 4 vertebrae
- Destructive, collapse
- ➔ Angular kyphosis
- No lesion on the posterior arch
- Abscess anterior spinal impression

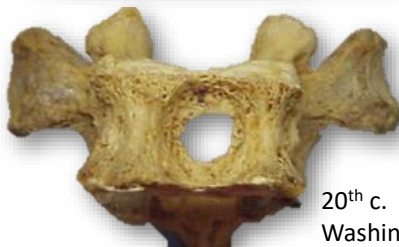
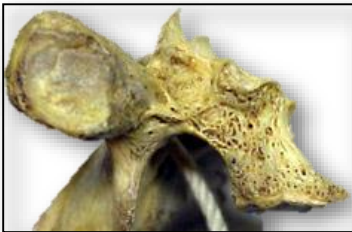
18/49 Menard & Lannelongue 1888; Sorrel & Sorrel Dejerine 1932

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Tuberculosis (4)

Cystic forms

Granuloma, no collapse



20th c.

Washington, Terry Collection

Vertebral diffuse anterior superficial lesions



Guadeloupe, 18th c.



19/49 Menard & Lannelongue 1888; Sorrel & Sorrel Dejerine 1932

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Tuberculosis (5)

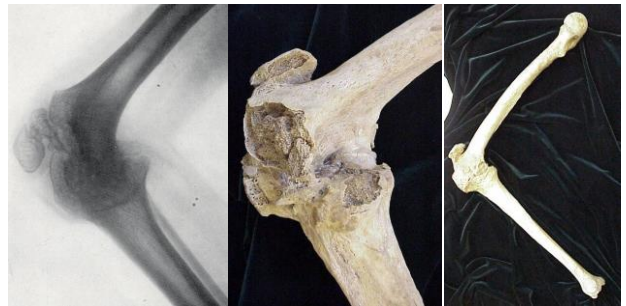
Non vertebral lesions

- **Long bones:**
 - Metaphyseal site of infection (hematogenous)
 - Extension: osteomyelitis

- **Articulations:**
 - hematogenous or from the osteomyelitis
 - Usually unilateral and monoarticular
 - Mirrored lesion
 - Slow development toward articular destruction and ankylosis



Hungary, Middle Age



20/49 Menard & Lannelongue 1888; Sorrel & Sorrel Dejerine 1932

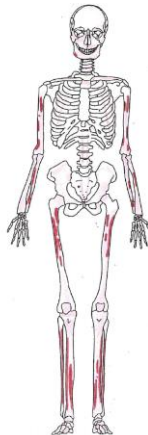
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Tuberculosis (6)

Hypertrophic pulmonary osteoarthropathy
(HOA)

rib lesions
subperiosteal reactions on the
visceral face

Serpens Endocrania
Symetrica (SES)
Tuberculous leptomenigitis

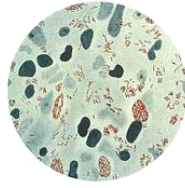


21/49 Baker et al., Masson et al. 2013, *Tuberculosis*; Hershkovitz et al. 2002, *Am. J. Phys. Anthropol.*

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Leprosy (1)

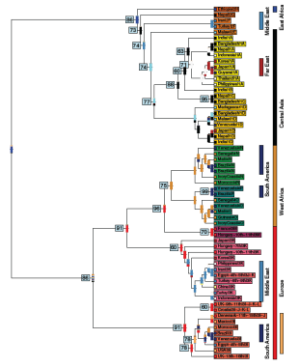
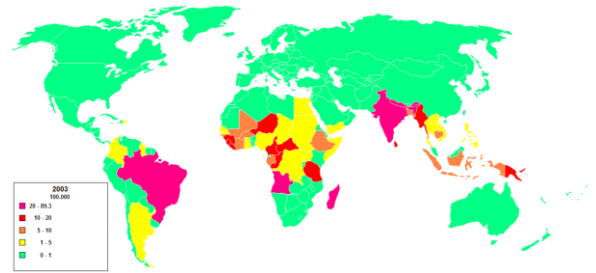
Mycobacterium leprae



- Low **contagiosity**
- Infection after a long exposition to cutaneous lesions or mucosa
- **Long incubation** (2 to 10 years)
- **Risk factors** (malnutrition, low immunity)
- ~ *10 millions* people today (WHO, 2013)

- Disease peripheral nerves and respiratory mucosa
- Known from antiquity (Papyrus Ebers, 1550 BC)
- Oldest paleopathological case: India, 2000 BC

- 2 main forms:
 - **Tuberculoid leprosy**, the most frequent
 - **lepromatous leprosy**



- Branch 1: Asia
- Branch 2: ME, East Africa
- Branch 3: Europe, America
- Branch 4: Africa, America

22/49 Monot et al. 2009, Nat. Gen.; Schuenemann et al. 2013, Science; Robbins et al. 2009



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Leprosy (2)

Tuberculoid leprosy

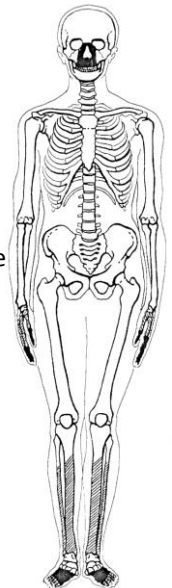
- Skin lesions (depigmentation, rash)
- Neurological disorders (insensitivity)
- Hypertrophy of nerve trunks (paralysis)
- **osteolysis of phalanges**

Lepromatous leprosy

- Larger skin lesions: disseminated lepromas (*leonine facies*)
- Leprous rhinitis (**rhinomaxillary syndrome**)
- **Necrosis of extremities**, loss of fingers and toes)
- Visceral involvement (liver, lymph nodes, testicles)



- **rhinomaxillary syndrome**
- Direct action of the bacteria
- **Acro-osteolysis**
 - Secondary to neurological disorders
 - Signs of infections



23/49 Leloir 1886, *Traité pratique et théorique de la lèpre*



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Leprosy (3)



Rhinomaxillary syndrome

- Osteolysis of nasal spine
- Erosion of the nasal opening edges (piriform notch)
- Resorption of anterior incisor tooth sockets (ante-mortem loss)
- resorption and perforation of the palate

Acro-osteolysis

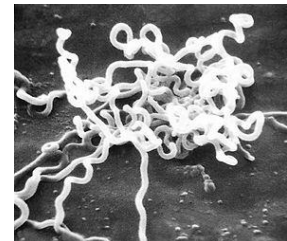
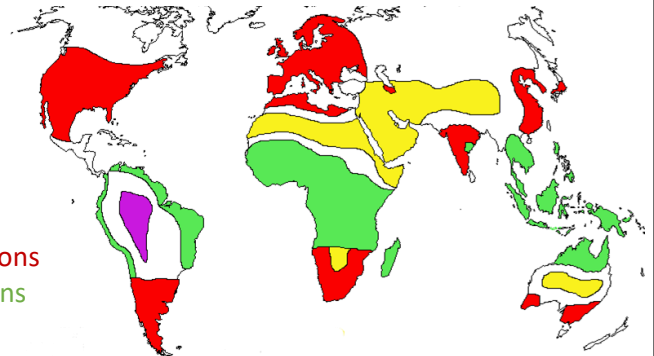
- Tubular bones, partial or total bone loss
- necrosis and amputation of the extremities



10th c., Hungary

Treponematoses (1)

- Bacteria, 4 sub-species of *Treponema pallidum*:
 - *T. p. pallidum*, syphilis, industrialized regions
 - *T. p. pertenue*, yaws, humid tropical regions
 - *T. p. endemicum*, bejel, arid regions
 - *T. p. carateum*, pinta, South America
- No bacteriological differences
- Clinic expression linked to the transmission mode and climate



Treponematosi (2)

3 evolutive phases
(for syphilis, yaws, bejel):

- **Primary (weeks)**

Inoculation chancre (sexual, cutaneous, mucosal)

- **Secondary (months)**

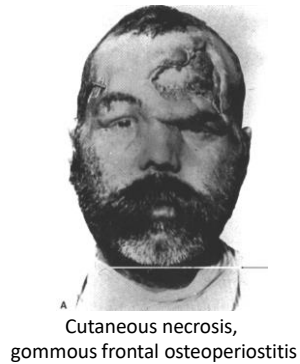
Cutaneous lesions (syphilides, roseola, pianoma)

- **Tertiary (years)**

Visceral lesions (cardiovascular, neurological, **bone**, etc.)



Wax sculpture 208, secondary syphilis



Cutaneous necrosis, gummous frontal osteoperiostitis



Tibial osteoperiostitis

26/49 Tilles & Wallach 1996, *Le musée des moulages de l'hôpital Saint-Louis*.

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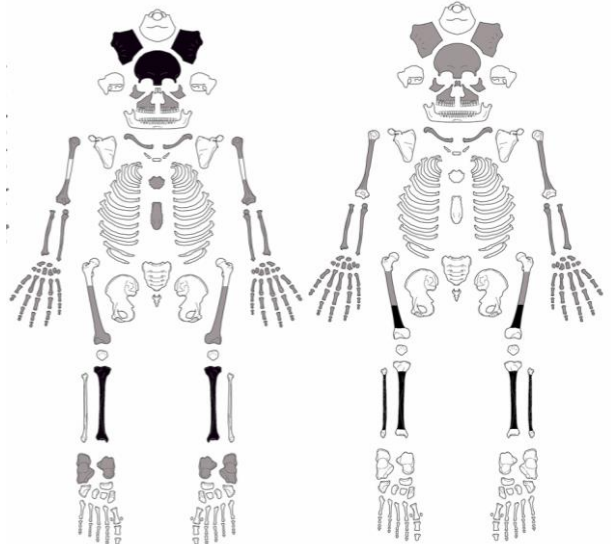


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Treponematosi (3)

- Tertiary treponematosi
- Same lesions but different frequencies
- 2 main locations
 - **Frontal bone: caries sicca**
 - **Tibia: gummous osteoperiostitis**
- other locations, rarer
 - distal, proximal humerus
 - manubrium / clavicles
 - distal femur
 - hands (dactylitis, spina ventosa)



Syphilis
10 to 20 %

Yaws/Bejel
1 to 5 %

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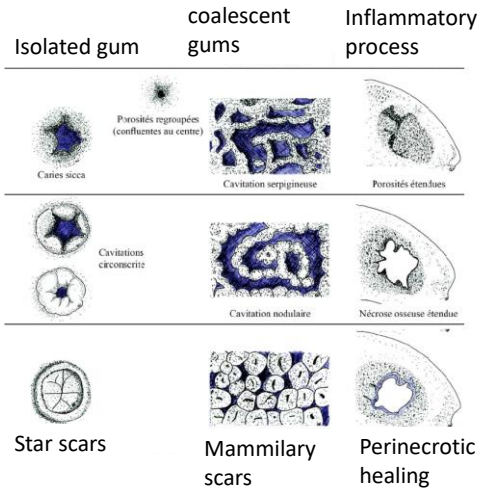


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Treponematosi (4)

Frontal bone osteoperiostiti: *caries sicca*



28/49 Hacket, 1976

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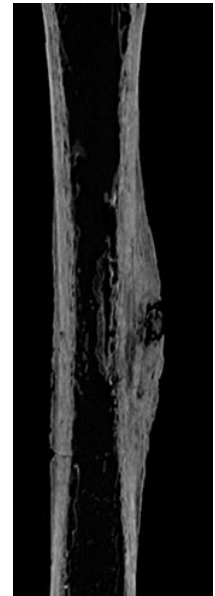
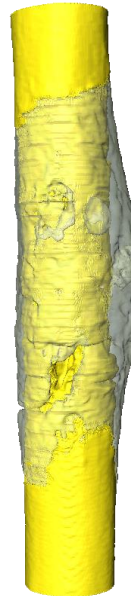
Treponematosi (4)



Gummosis osteoperiostiti



Saber shin tibial osteoperiostiti



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Deficiencies

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Metabolic diseases

- Diseases of the phosphocalcic metabolism
 - genetic (vitamino-resistant rickets)
 - **deficiency** (Vit. C, D),
 - endocrinian (thyroid, pituitary gland malfunction)
 - diseases of glucidic, lipidic metabolisms
- No consensus in paleopathology

Aufderheide, 1998	Ortner, 2003	Pinhasi et Mays, 2008	Waldron, 2008
Vit. D (rickets & osteomalacia)			
Vit. C (Scurvy)			
Osteoporosis / osteopenia			
poisoning (F, Pb, Hg, As)	Fluorosis		
	Hyperostosis	Paget's disease	Paget's disease
	Hypophosphatasia		DISH
			Anemia
			Thyroid hormones diseases

30/49

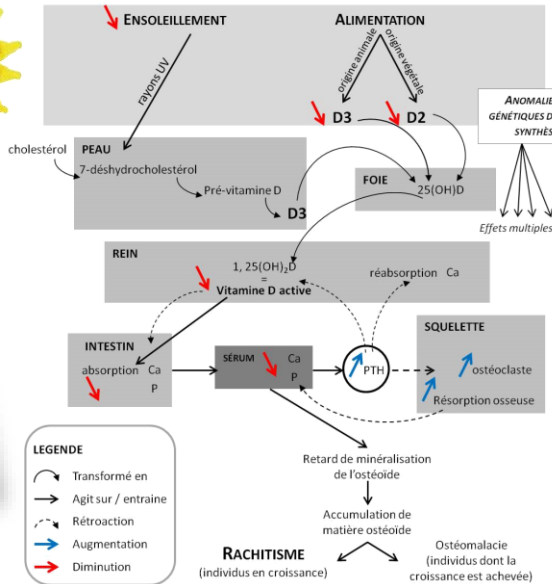
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Rickets (1)



Severe vitamin D deficiency



10 µg/day

250 µg/100g



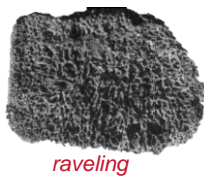
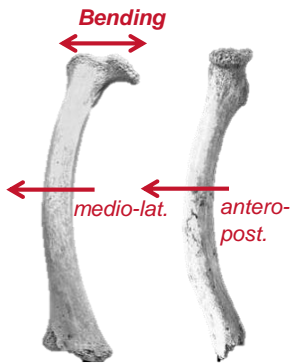
30 - 55 µg/100g



Up to 13 µg/100g

31/49 Beylard, 1892

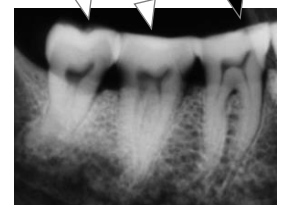
Rickets (2): paleopathological signs



X-ray transparency



Skull cortical porosities



Pulp chamber deformation

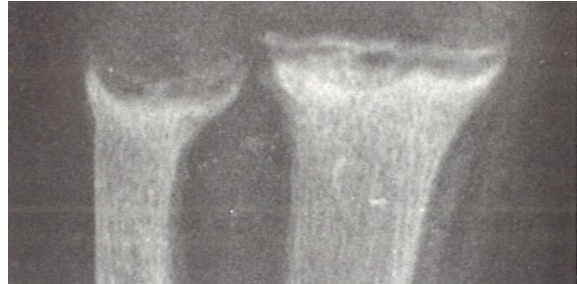
32/49 Brickley et Ives, 2008 ; Veselka et al. 2015, Int. J. Paleopathol. ; Mays et al. 2006, Am. J. Phys. Anthropol. ; d'Ortenzio et al. 2016, J. Archeol. Sci.

Rickets (3): active / healed?

Clinical studies : Active rickets



Healing rickets



- Mineralization line

In paleopathology ?

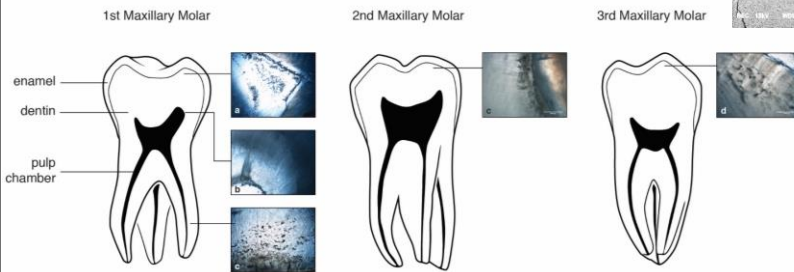
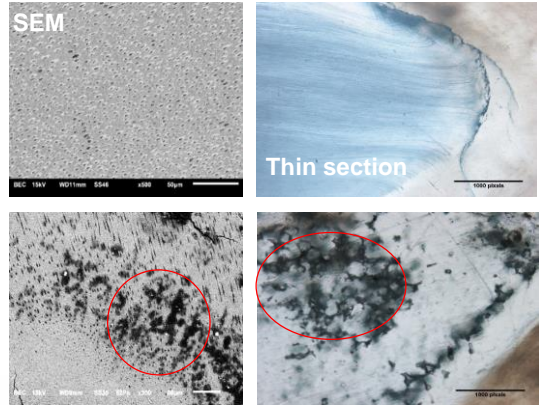
Rickets (4): residual deformations in adults



- Disappearance of most of the bone modifications
- Expect bone bending
- **differential diagnosis mandatory**

Rickets (4): tooth lesions

- Hypoplasias (non specific)
- **Interglobular dentin** (bad mineralization of the dentin) specific of vitamin D deficiency



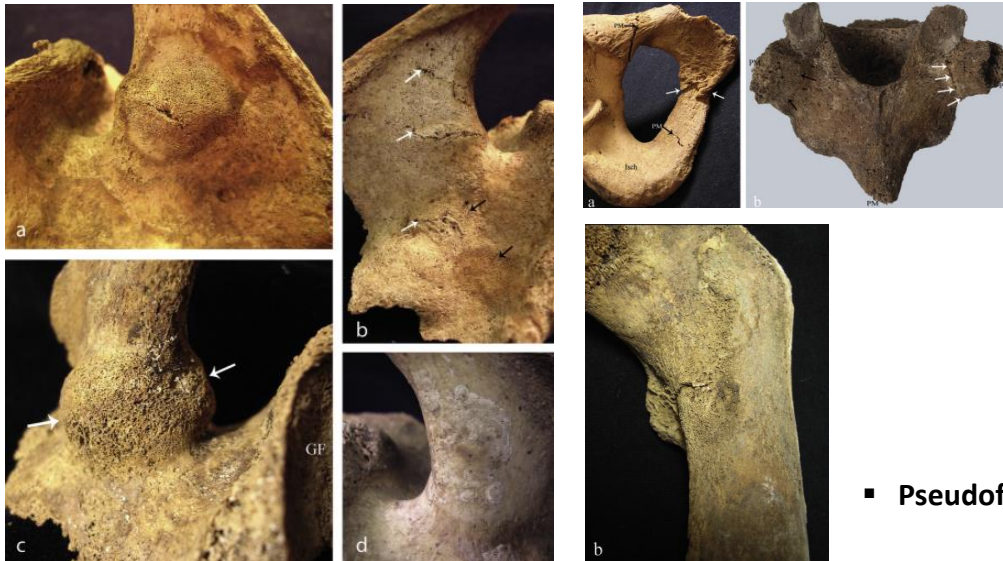
- Number and timing of deficiency events through the development

→ Vit. D def. paleoepidemiology

35/49 d'Ortenzio et al. 2017, *Int. J. Paleopathol.*; d'Ortenzio et al. 2016, *J. Archeol. Sci.*



Adults vitamin D deficiency: osteomalacia



- Pseudofractures

36/49 Ives & Brickley 2014, *Int. J. Paleopathol.*



Scurvy (1)

daily: 60 mg /day Vit. C deficiency (ascorbic acid)



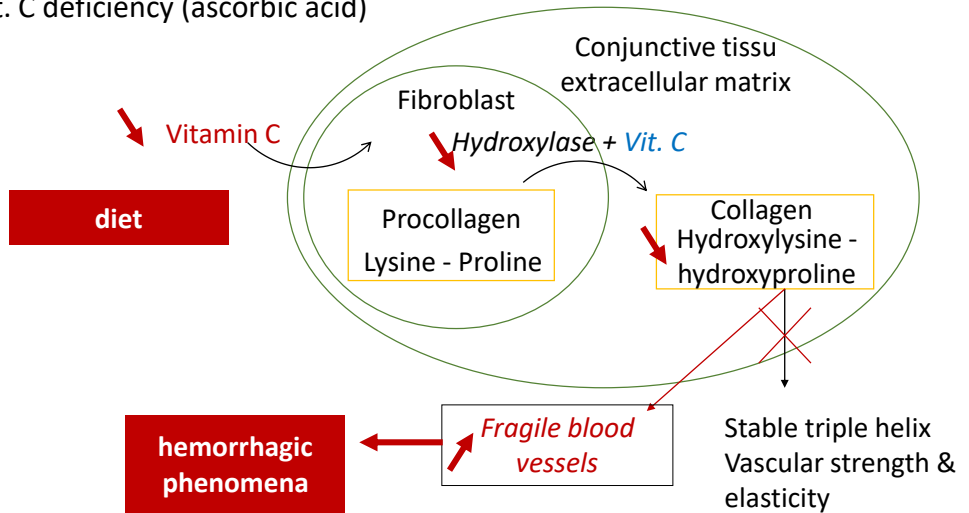
183 mg/100g



133 mg/100g



53 - 61 mg/100g



37/49



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Scurvy (2)

- Fatigue
- Hemorrhages, bruises
- Gum pain and bleeding
- Tooth loosening and loss
- Poor healing
- Swelling of joints in particular
- **DEATH**



38/49



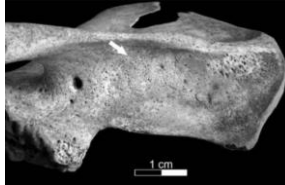
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Scurvy (3)

- Bleeding = low intensity trauma
- hemorrhages → inflammatory reaction
- **microporosities** < 1 mm

→ sphenoid great wings, posterior face of the maxillary bone, mandible, skull vault and orbit, infra & supra epinous fossa of the scapula, long bones metaphysis



± ante/perimortem teeth loss, new bone formation, bone loss & fractures



▪ **Children:** growth, anemia, etc.

39/49 Brickley & Ives, 2005; Geber & Murphy 2012, Am. J. Phys. Anthropol.



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Scurvy (4) Location of diagnostic scurvy lesions in paleopathology (12/25)

Location	Type	Clinical studies
Outer surface of parietal bones and squamous part of temporal bone	Cortical porosities (CP), Subperiosteal new bone formation (SPNB)	Indirect (Barlow, 1883)
Sphenoid: great wings	CP, SPNB	-
Sphenoid: <i>foramen rotundum</i>	SPNB	-
Sphenoid: pterygoid fossa	CP, SPNB	-
Orbital roof	CP, SPNB	Indirect
Maxillary: anterior surface, infraorbital foramen	CP, SPNB	-
Maxillary: posterior surface	CP, SPNB	-
Maxillary: palate surface	SPNB	-
Mandible: internal face, coronoid process	CP, SPNB	-
Scapula: supra-epinous fossa	CP	Indirect (Barlow, 1883)
Scapula: infra-epinous fossa	CP, SPNB	Indirect (Barlow, 1883)
Long bones diaphysis-metaphysis	Diffuse SPNB	Direct

Possible diagnostic: ≥ 2 DL, **probable diagnostic:** 1 DL + several SL

40/49 Snoddy et al. 2018, Am. J. Phys. Anthropol.

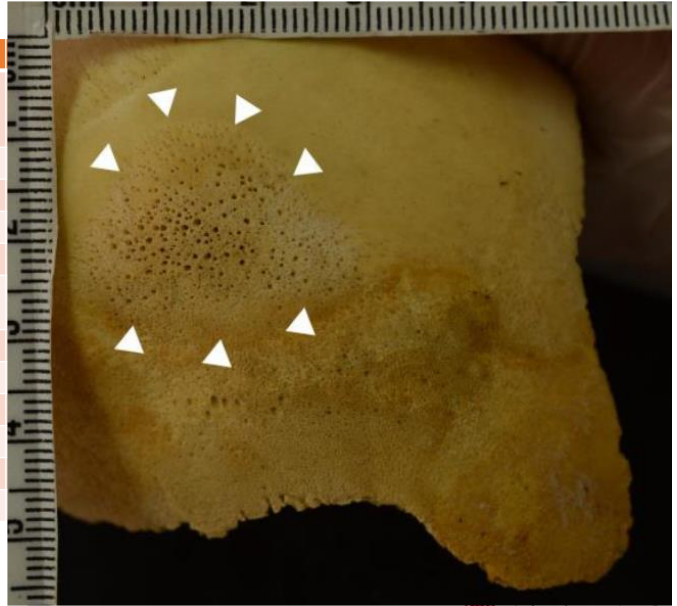


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Scurvy (5) Location of diagnostic scurvy lesions in paleopathology (12/25)

Location
Outer surface of parietal bones and squamous part of temporal bone
Sphenoid: great wings
Sphenoid: <i>foramen rotundum</i>
Sphenoid: pterygoid fossa
Orbital roof
Maxillary: anterior surface, infraorbital foramen
Maxillary: posterior surface
Maxillary: palate surface
Mandible: internal face, coronoid process
Scapula: supra-epinous fossa
Scapula: infra-epinous fossa
Long bones diaphysis-metaphysis



Possible diagnostic: ≥ 2 DL

probable diagnostic: 1 DL + several SL

41/49 Snoddy et al. 2018, Am. J. Phys. Anthropol.

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PSL

Scurvy (6) Location of diagnostic scurvy lesions in paleopathology (12/25)

Location	Type	Clinical studies
Outer surface of parietal bones and squamous part of temporal bone		
Sphenoid: great wings		
Sphenoid: <i>foramen rotundum</i>		
Sphenoid: pterygoid fossa		
Orbital roof		
Maxillary: anterior surface, infraorbital foramen		
Maxillary: posterior surface		
Maxillary: palate surface		
Mandible: internal face, coronoid process		
Scapula: supra-epinous fossa		
Scapula: infra-epinous fossa		
Long bones diaphysis-metaphysis		



Possible diagnostic: ≥ 2 DL

probable diagnostic: 1 DL + several SL

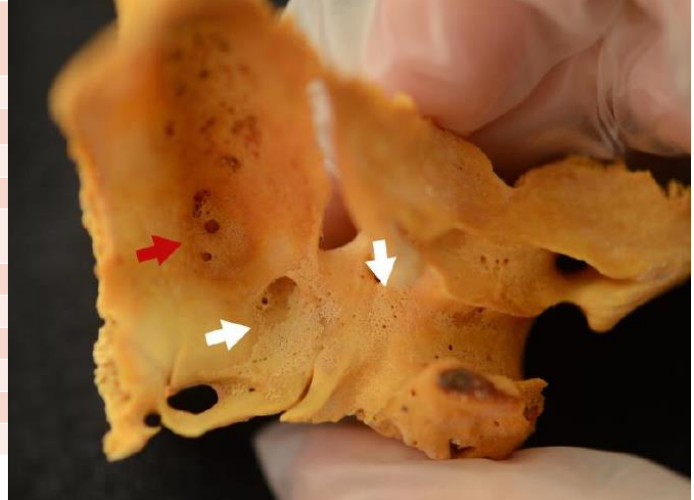
42/49 Snoddy et al. 2018, Am. J. Phys. Anthropol.

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Scurvy (7) Location of diagnostic scurvy lesions in paleopathology (12/25)

Location	Type	Clinical studies
Outer surface of parietal bones and squamous part of temporal bone		
Sphenoid: great wings		
Sphenoid: <i>foramen rotundum</i>		
Sphenoid: pterygoid fossa		
Orbital roof		
Maxillary: anterior surface, infraorbital foramen		
Maxillary: posterior surface		
Maxillary: palate surface		
Mandible: internal face, coronoid process		
Scapula: supra-epinous fossa		
Scapula: infra-epinous fossa		
Long bones diaphysis-metaphysis		



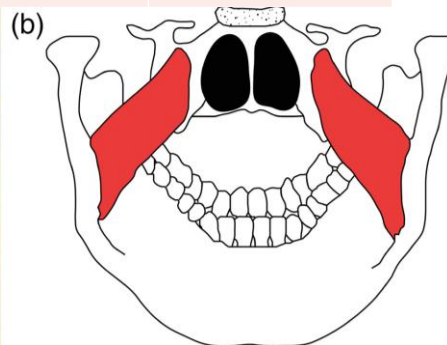
Possible diagnostic: ≥ 2 DL

probable diagnostic: 1 DL + several SL

43/49 Snoddy et al. 2018, Am. J. Phys. Anthropol.

Scurvy (8) Location of diagnostic scurvy lesions in paleopathology (12/25)

Location	Type	Clinical studies
Outer surface of parietal bones and squamous part of temporal bone	Cortical porosities (CP), Subperiosteal new bone formation (SPNB)	Indirect (Barlow, 1883)
Sphenoid: great wings	CP, SPNB	-
Sphenoid: <i>foramen rotundum</i>	SPNB	-
Sphenoid: pterygoid fossa	CP, SPNB	-




Possible diagnostic:

probable diagnostic: 1 DL + several SL

44/49 Snoddy et al. 2018, Am. J. Phys. Anthropol.

Scurvy (9) Location of diagnostic scurvy lesions in paleopathology (12/25)

Location	Type	Clinical studies
Outer surface of parietal bones and squamous part of temporal bone		
Sphenoid: great wings		
Sphenoid: <i>foramen rotundum</i>		
Sphenoid: pterygoid fossa		
Orbital roof		
Maxillary: anterior surface, infraorbital foramen		
Maxillary: posterior surface		
Maxillary: palate surface		
Mandible: internal face, coronoid process		
Scapula: supra-epinous fossa		
Scapula: infra-epinous fossa		
Long bones diaphysis-metaphysis		



Possible diagnostic: ≥ 2 DL


probable diagnostic: 1 DL + several SL

45/49 Snoddy et al. 2018, Am. J. Phys. Anthropol.

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Scurvy (10) Location of diagnostic scurvy lesions in paleopathology (12/25)

Location	Type	Clinical studies
Outer surface of parietal bones and squamous part of temporal bone		
Sphenoid: great wings		
Sphenoid: <i>foramen rotundum</i>		
Sphenoid: pterygoid fossa		
Orbital roof		
Maxillary: anterior surface, infraorbital foramen		
Maxillary: posterior surface		
Maxillary: palate surface		
Mandible: internal face, coronoid process		
Scapula: supra-epinous fossa		
Scapula: infra-epinous fossa		
Long bones diaphysis-metaphysis		



Possible diagnostic: ≥ 2 DL

probable diagnostic: 1 DL + several SL

46/49 Snoddy et al. 2018, Am. J. Phys. Anthropol.

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Scurvy (11)

For adults

- Ante mortem teeth loss
- Porosities of the mandible alveolar margin
- Cranial porosities
- Long bones SPNB (ossified hematoma)
- *Impacted fractures and rib fractures*



47/49 van de Merwe et al. 2010, *Int. J. Osteoarcheol.*

Scurvy & rickets co-occurrence (1)



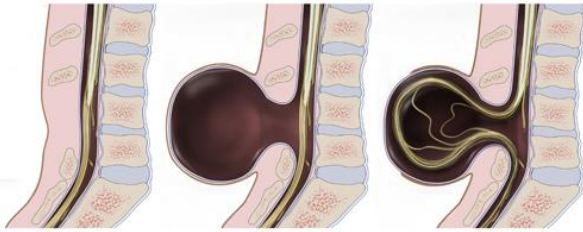
- Douai (France), 16th – 18th c.
- 48 children < 5 y.o.
- macroscopical, radiological, microscopical analyses



48/49 Schattman et al. 2016, *Int. J. Paleopathol.*

Spina bifida occulta (1)

- Deficiency in folic acid (Vit. B9) during pregnancy
- Vit. B9 deficiency may cause anemia



Spina bifida occulta

Meningocele

Myelomeningocele



Děkuji !