BIO VERREs

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Le squelette

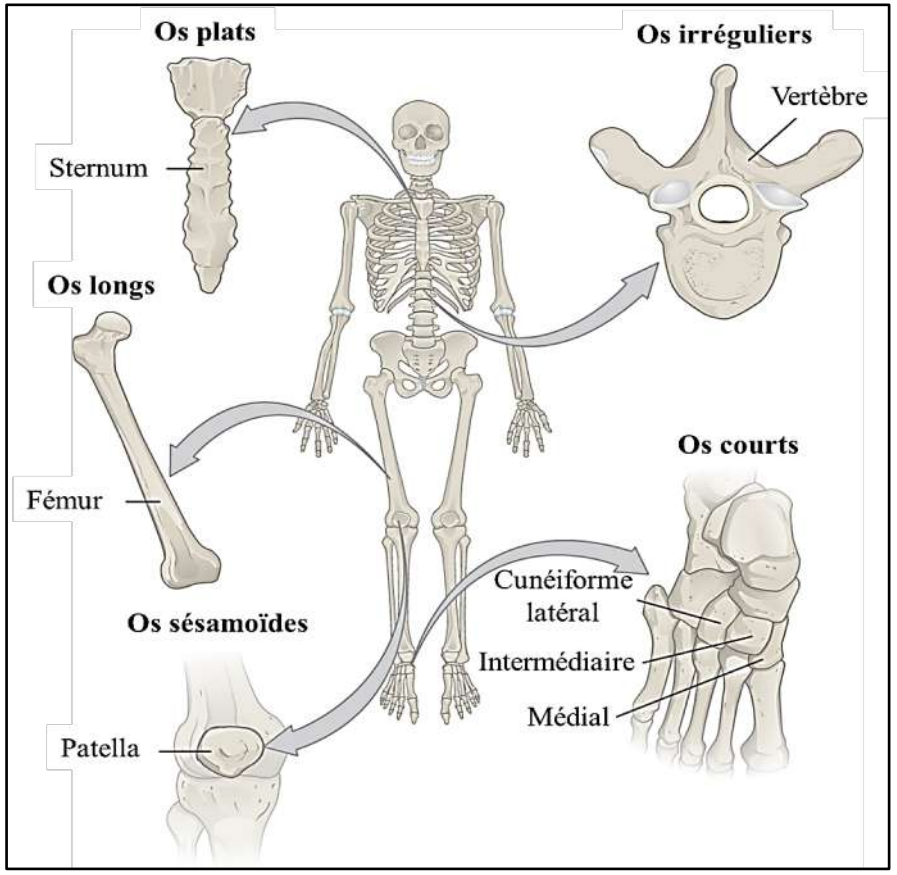
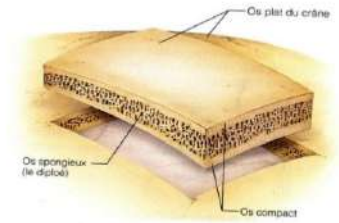


Figure 1 : Classification à cinq catégories des pièces osseuses du squelette humain. Modifié d'après[16].

Constitution du tissu osseux



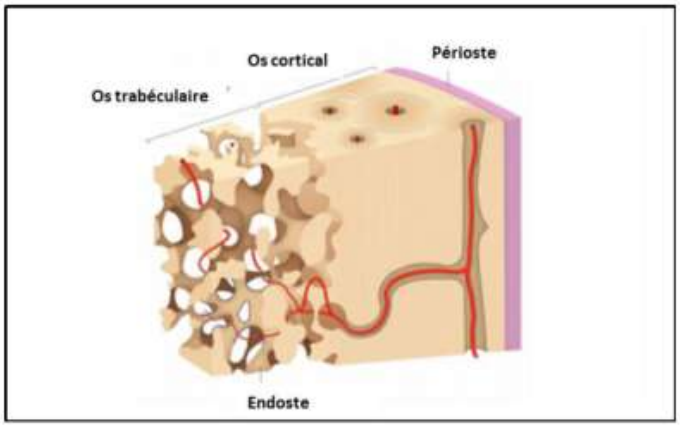
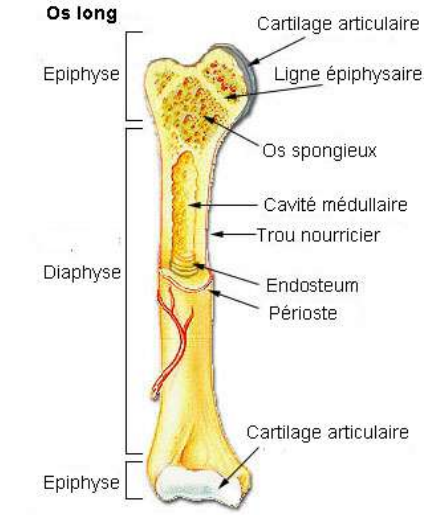


Figure 1 : schéma de l'architecture du tissu osseux (5).

Morrison SJ, Vol. 505,. Nature; 2014



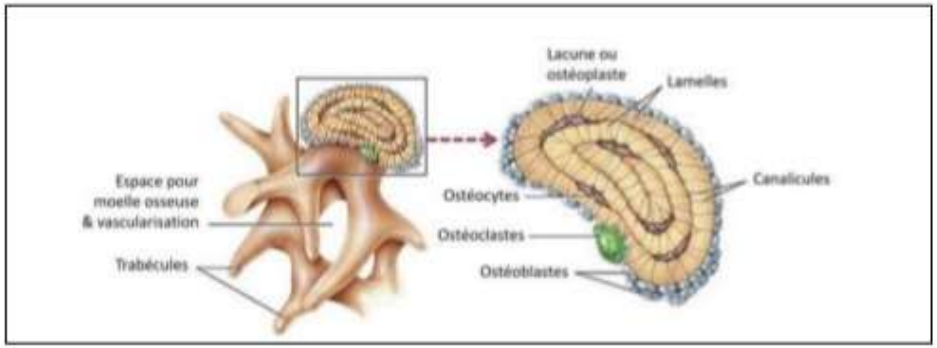


Figure 3 : Représentation schématique de l'os trabéculaire (8).

Wang X, Biomaterials. 2016

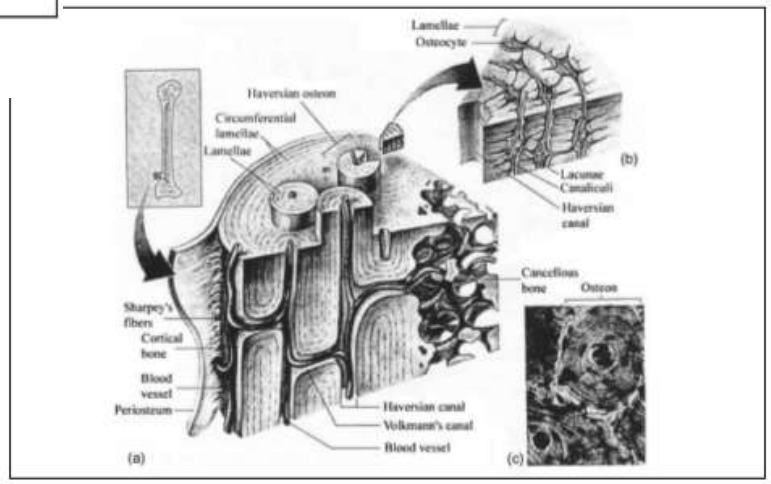


Figure 2 : Structure microscopique de l'os cortical (A) représentation 3D de l'os cortical, (B) coupe du système Haversien (C) photomicrographie du système Haversien (7).

Doblaré M, Engineering Fracture Mechanics. 2004

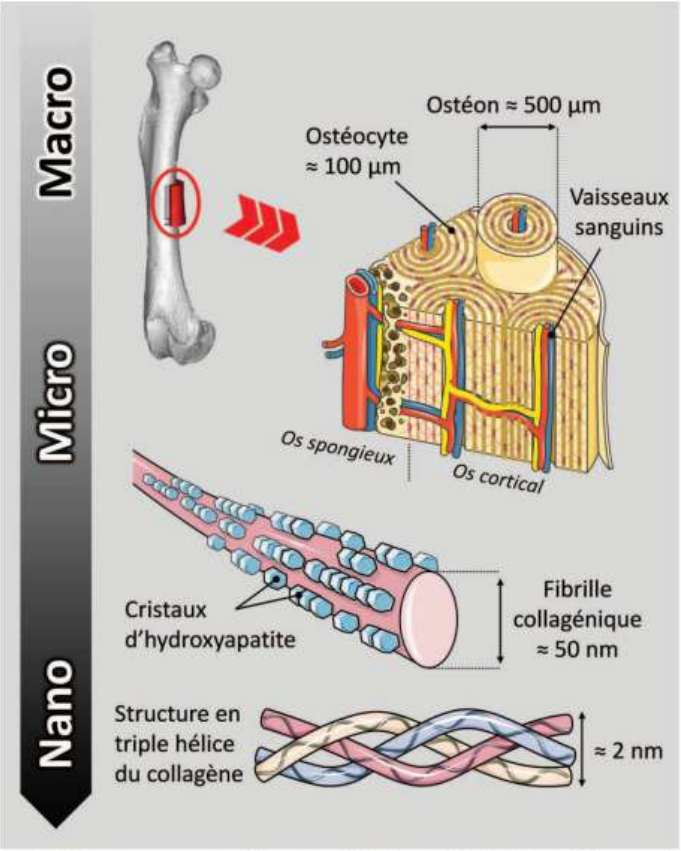


Schéma des différentes composantes de l'os naturel à différentes échelles (courtoisie banque d'images

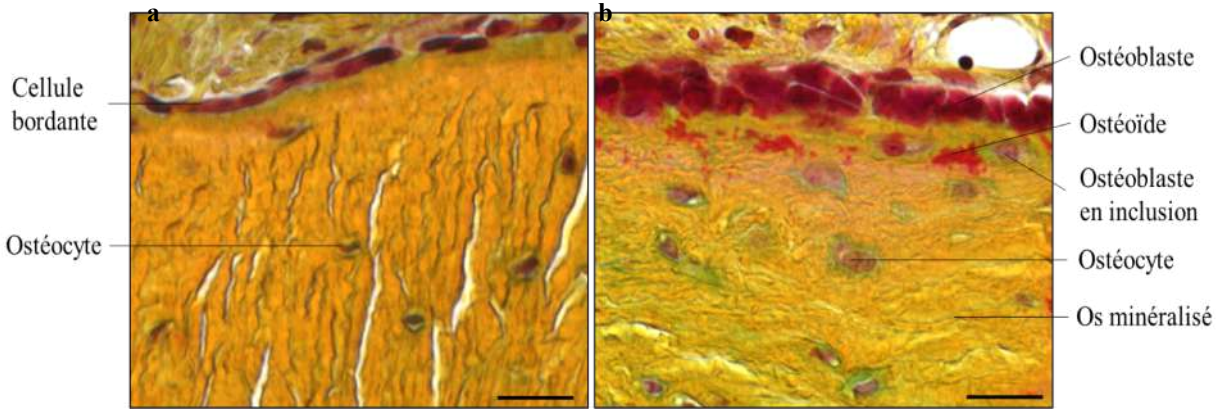


Figure 3 : Observation histologique de tissu osseux. Coloration au pentachrome de Movat. Jaune : collagène, brun : noyaux cellulaires, rouge : barrière ostéoïde. (a) Tissu osseux stable, (b) tissu osseux en formation. Barres d'échelles : 50 µm.

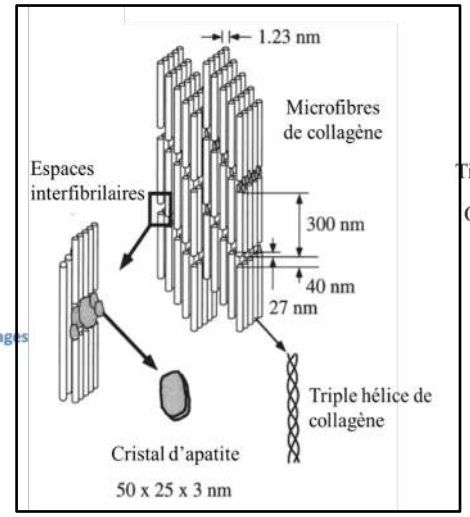


Figure 5 : Organisation submicronique de la matrice osseuse[22]

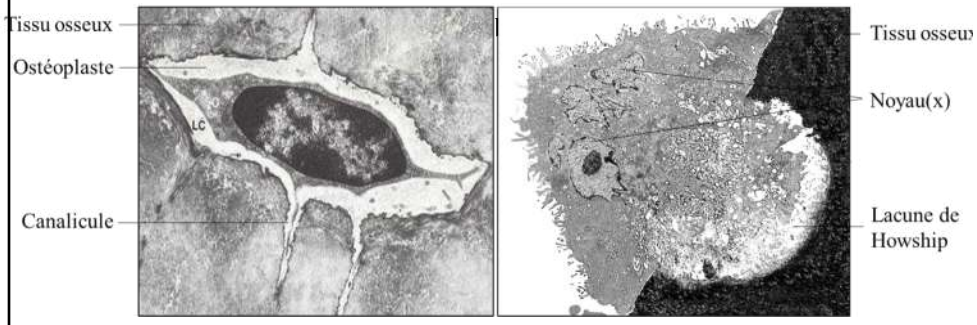


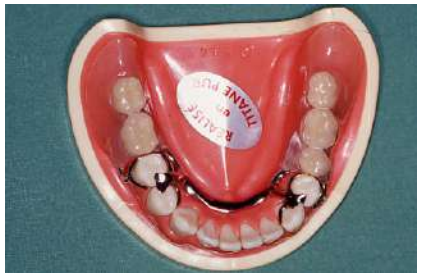
Figure 4 : (a) Observation d'un ostéocyte (généralement 15-30µm) dans son ostéoplaste et (b) un ostéoclaste (généralement 50-100µm) en activité (Pillet, P./Guicheux, J. non publié). Microscope électronique à transmission.

https://alliancerm.org/

La médecine Régénératrice

La médecine 4R

Replace

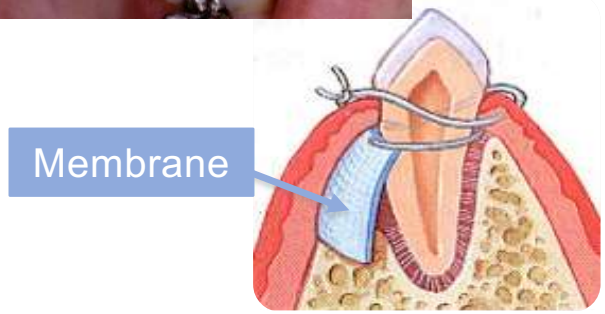


On remplace un organe par un objet qui rétablit une fonction : Mécanique et DM

Repair

On répare une partie d'un organe
avec un biomatériau bioactif pour rétablir une fonction mécanique et biologique
Matériaux osteo-conducteur

Regenerate

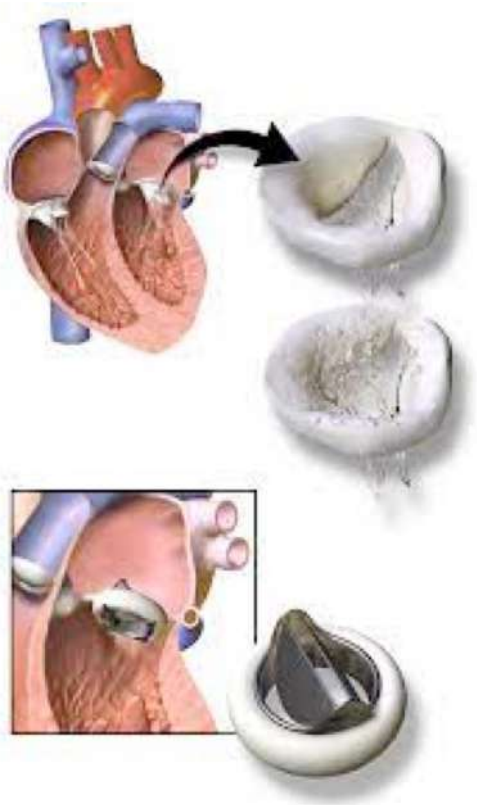


On régénère *ad integrum* une partie d'un organe
avec un biomatériau, des cellules, des facteurs de croissance…

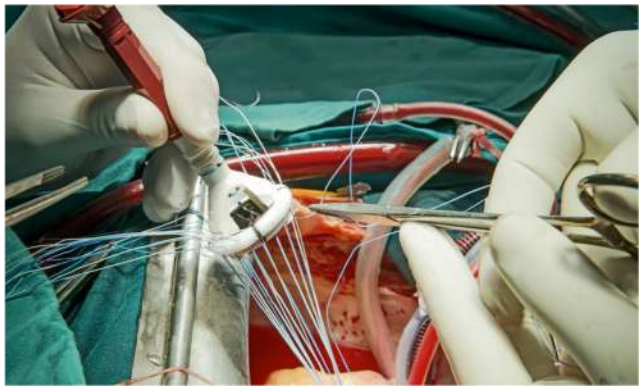
Reprogram

On reprogramme des cellules pour leur demander la régénération d'un tissu.
(Production de FC, IPS (cellules souches pluripotentes induites…)

Remplacer ou réparer ?



On répare le cœur
On remplace une valve ?



On remplace le cœur

Remplacer ou réparer ?

- On répare une partie d'un organe
- On remplace un organe
- Pour retrouver une fonction biologique

REGENERATION

On régénère *ad integrum* une partie d'un organe

avec un biomatériau, des cellules, des facteurs de croissance…

Remodelage osseux

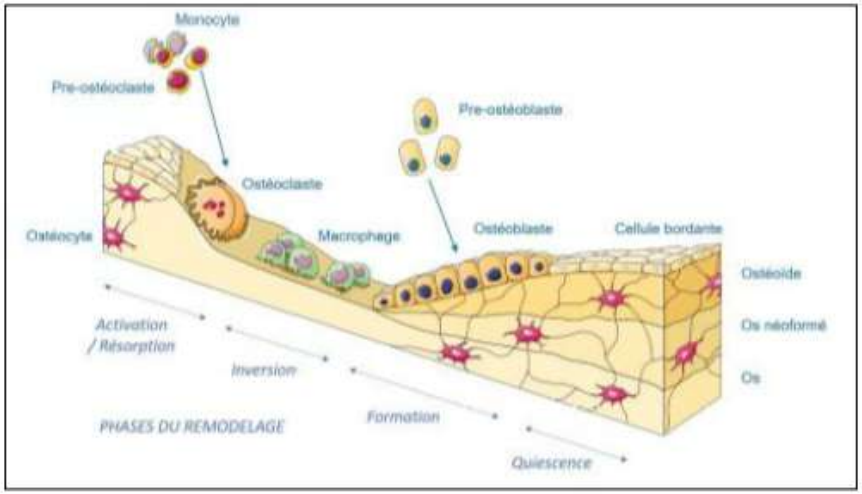


Figure 8 : Cycle du remodelage osseux (adaptée de la banque d'image SERVIER)

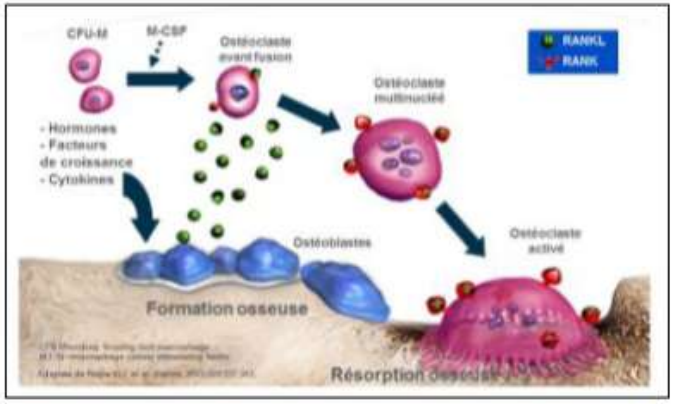


Figure 7 : Activation des ostéoclastes par les ostéoblastes par la sécrétion de différents facteurs solubles (M-CSF et RANK) (44).

Lebret T, Progres en Urologie. 2011.

La régénération osseuse spontanée

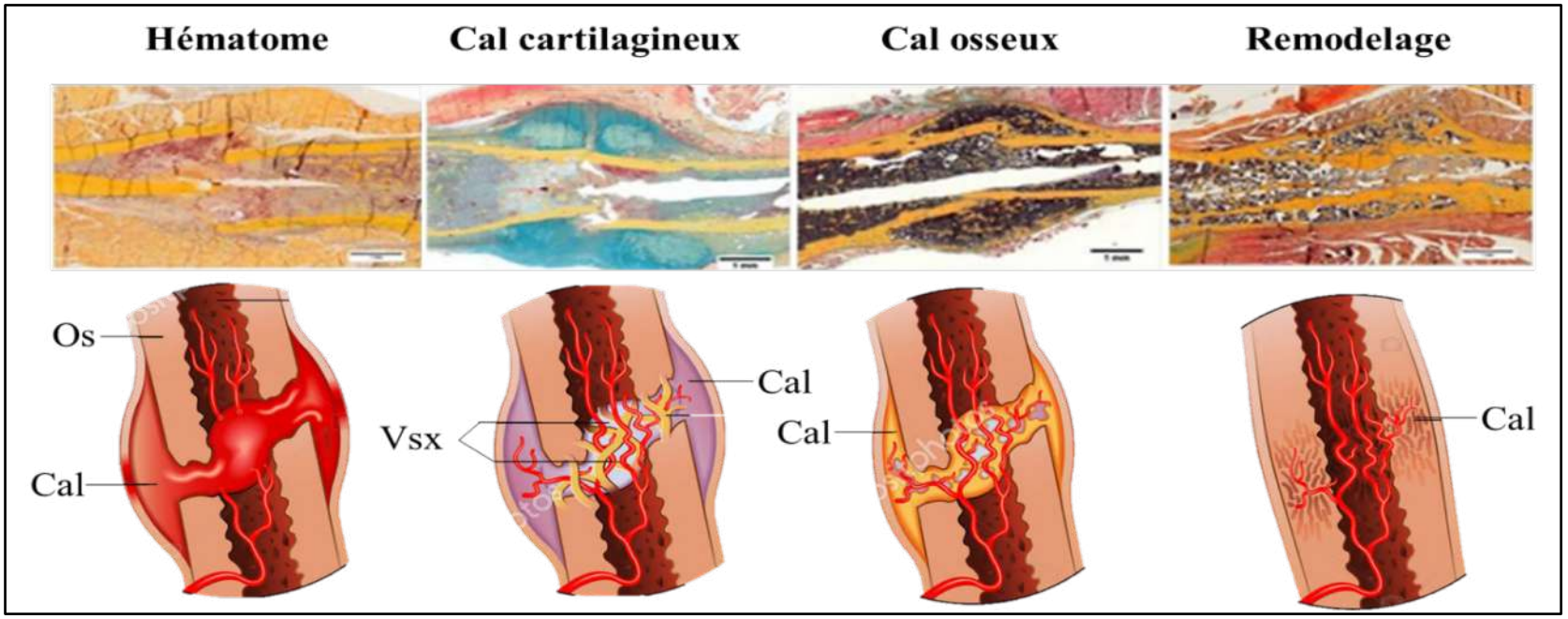
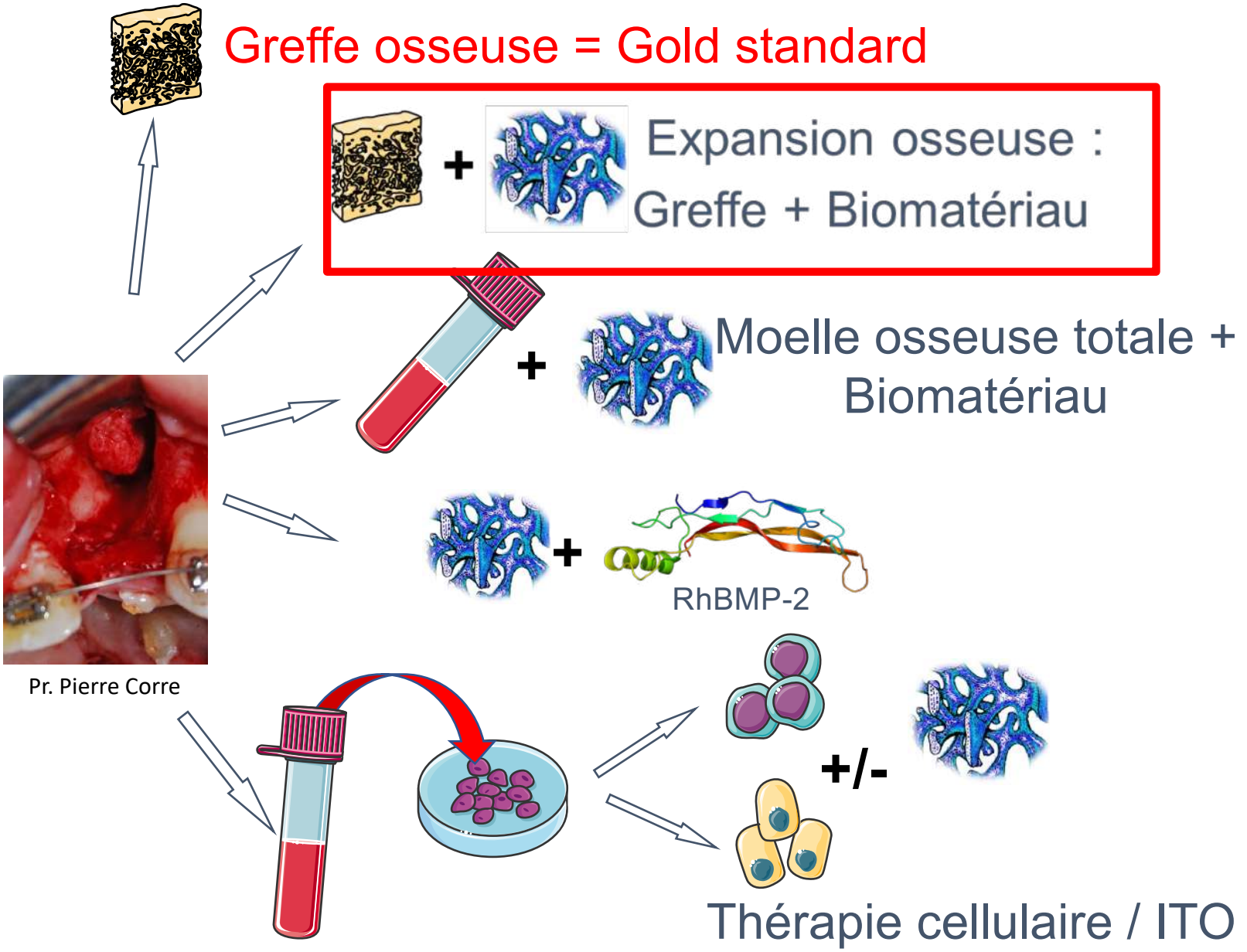


Figure 6 : Les grandes étapes de la régénération osseuse endochondrale. Vsx : vaisseaux sanguins. Modifié d'après Eweida AM, Arch Orthop Trauma Surg. 2012

Limites actuelles de la greffe autologue

- Taux d'échec de la GO
  - Enfant : 0%
  - Adulte: 10%
- Morbidité tibiale
  - Douleur: 5 jours
  - Boiterie: 10 jours
  - Cicatrice visible: 13%

Corre P *et al*. Intérêt du site de prélèvement tibial médio-proximal dans l'alvéoloplastie secondaire: expérience de 55 cas chez l'enfant. Rev Stomatol Chir Maxillofac. 2011 Nov;112(5):280-5

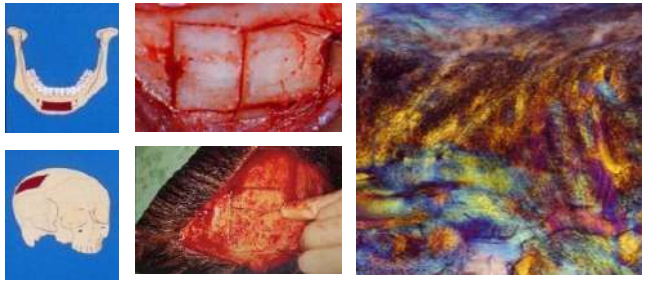

Greffe osseuse = Gold standard
Expansion osseuse :
Greffe + Biomatériau
Moelle osseuse totale +
Biomatériau
RhBMP-2
Pr. Pierre Corre
+/-
Thérapie cellulaire / ITO

ALTERNATIVES AUX GREFFES

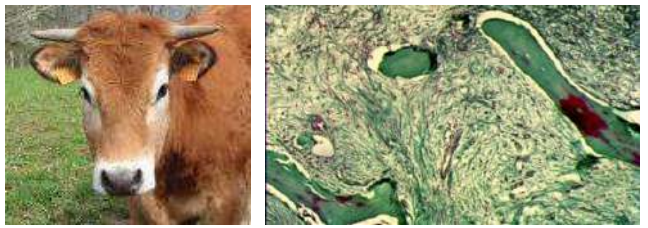
- BIOMATERIAUX
  - Petites cavités
  - Diffusion des protéines et migrations des cellules hôtes dans le matériaux.
  - Adhésion cellulaire puis remodelage
- INGÉNIERIE TISSULAIRE
  - Grosses pertes de substances
  - Cellules du patient multipliées *in vitro*
  - Réimplantées

Biomatériaux pour la régénération osseuse

- **Autogenous bone** (Gold Standard)
  - Stock d'os limité (petits paquets)
  - Risques de morbidité élevés
  - Douloureux et non esthétique

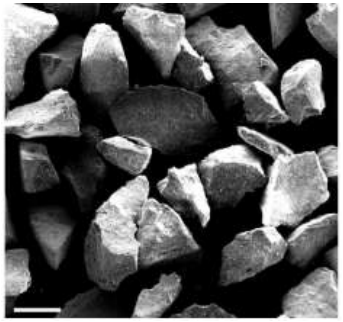


- **Allograft (Human)**
- **Xenograft bone (Animal)**
  - Infection (bactérienne - virale)
  - Les os morts limitent la prolifération des cellules
  - Exigences légales (origines biologiques)

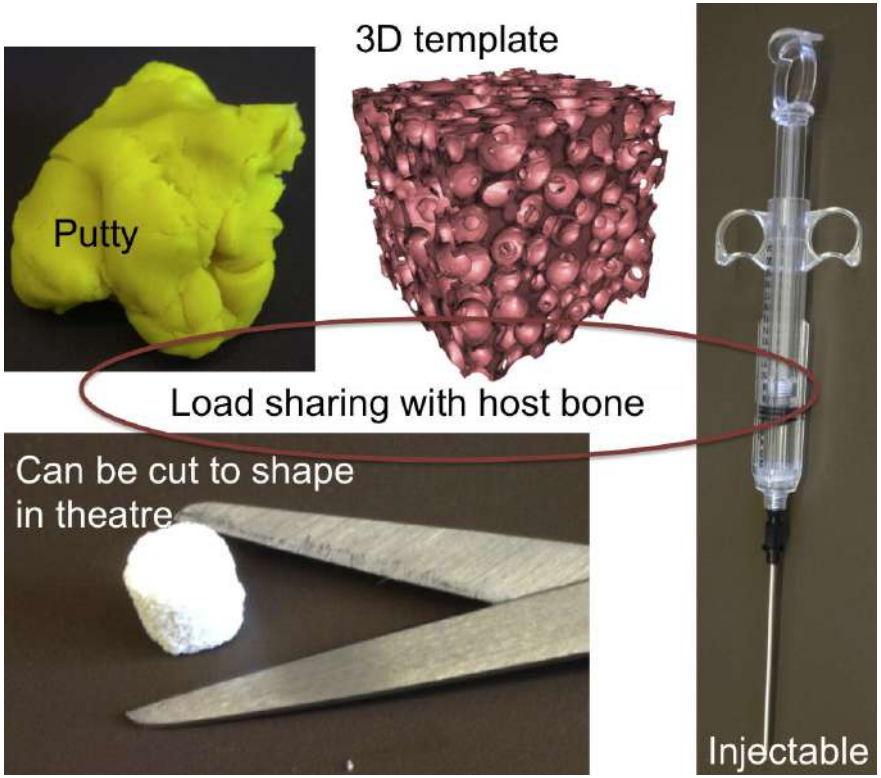


- **Phosphates de calcium**
  - Grande variété sur le marché
  - Qualité et résultats cliniques différents
  - Savoir-faire de production très spécifique

- **Bio VERRE**
  - Matériau synthétique controlé
  - Capable de recruter des cellules ostéoprogénitrices, les "cellules souches" de l'os.
  - contrôle le cycle des ostéoblastes pour favoriser la prolifération et la différenciation



Le design des Biomatériaux



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journal homepage: www.elsevier.com/locate/actabiomat

Review

Reprint of: Review of bioactive glass: From Hench to hybrids

Julian R. Jones *
Department of Materials, Imperial College London, South Kensington Campus, London SW7 2AZ, UK

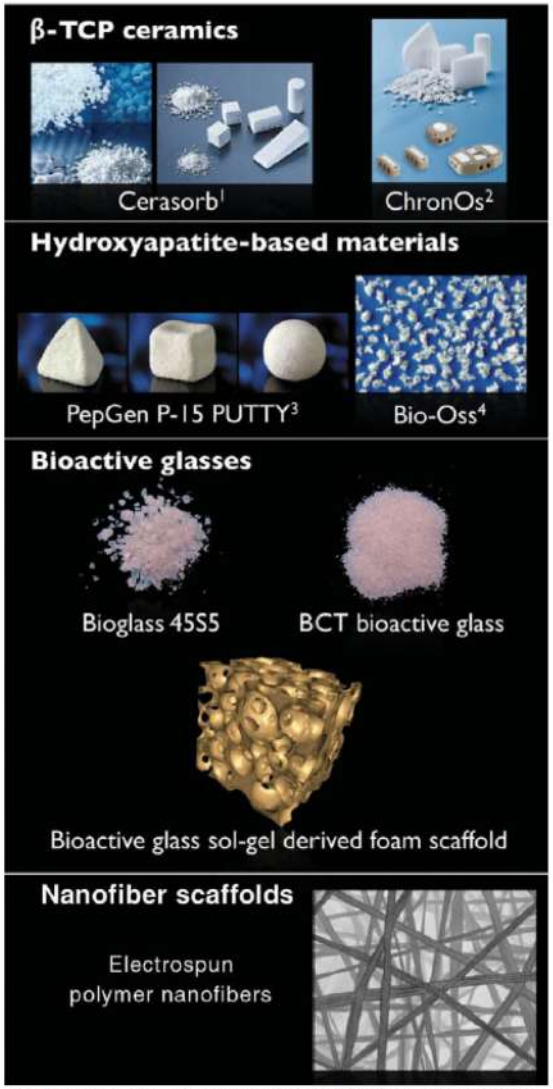
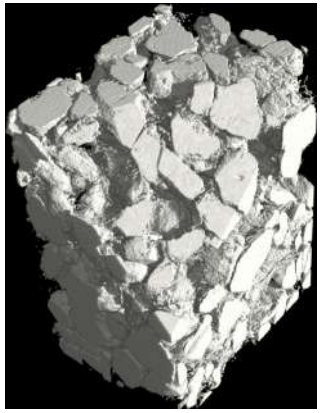
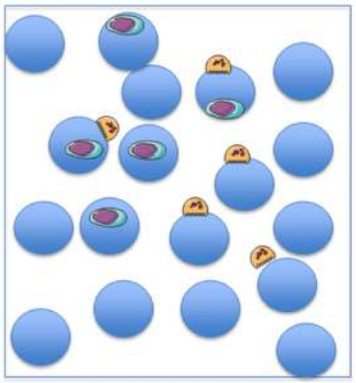
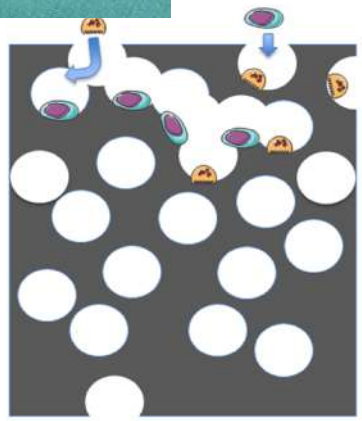


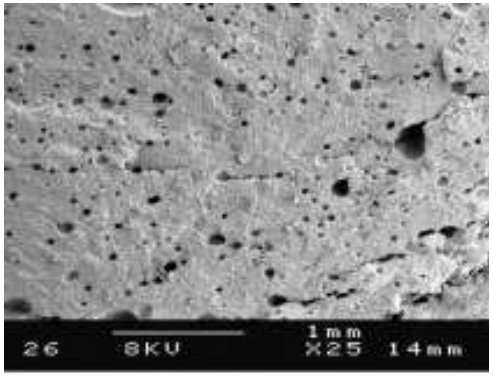
Fig. 2. Macromorphology of some examples of different bone graft materials. (Reproduced with permission from [1]Curasan AG, [2]Synthes, [4]Geistlich. [3]Courtesy of Dentsply Tulsa Dental Specialties. © PepGen® P-15.)

Les Substituts osseux injectables (IBS)

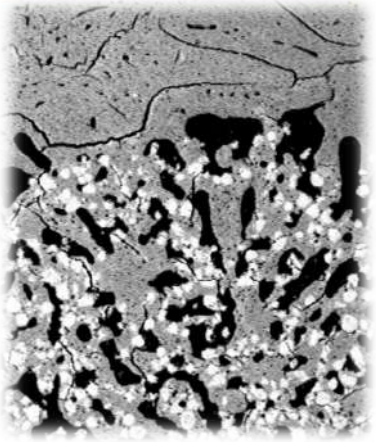


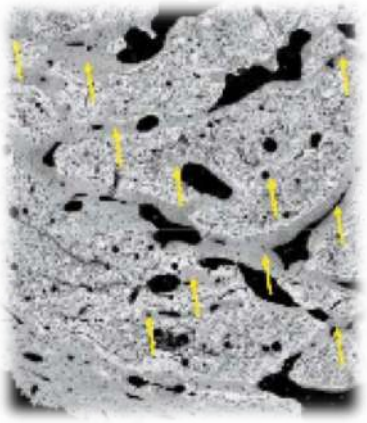


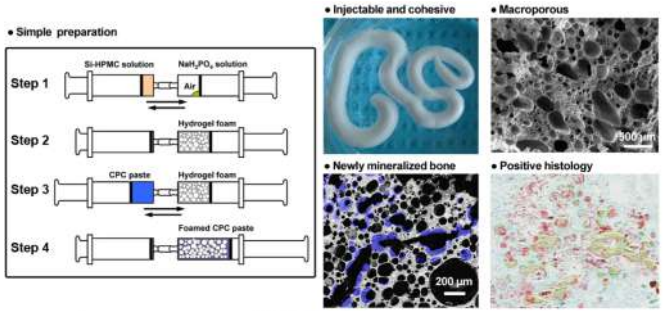


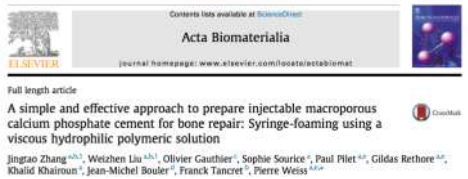


Macroporous and highly resorbable apatitic calcium-phosphate cement
Khairoun I, Weiss P, Bouler JM
Application WO2008023254





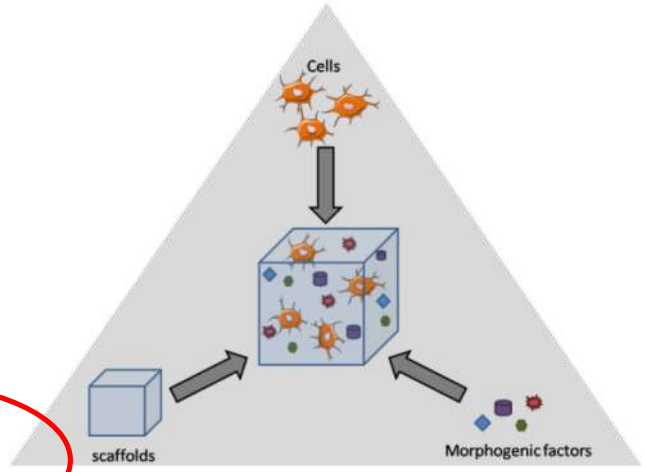




Définition de Ingénierie tissulaire

Un nouveau domaine biomédical regroupant les principes de la biologie cellulaire et du génie biologique, qui permet de reconstruire des structures proches des tissus à partir de cellules vivantes pour des usages in vivo ou ex vivo. Le concept clef en est la reproduction, avec des caractéristiques simplifiées, de l'architecture tissulaire, qui conduit à une intégration immédiate et interactive de ces tissus dans le corps humain (Auger, Canada)

Cellules



Biomatériaux/ matrices

Morphogènes

Merceron, Vinatier, Guicheux. Joint Bone Spine 2008
Vinatier, Guicheux. Trends Biotechnol 2009
Vinatier, Guicheux, Noël Curr Stem Cell Res Ther 2009

Les Apatites Biologiques et synthétiques

le minéral osseux:

- $Ca_{8,3}\ (PO_4)_{4,3}\ (HPO_4,CO_3)_{1,7}\ (OH,CO_3)_{0,3}$

le minéral de l'émail dentaire:

- $Ca_{9,4}\ (PO_4)_{5,4}\ (HPO_4,CO_3)_{0,6}\ (OH,CO_3)_{1,4}$

L'Hydroxyapatite

- $Ca_{10}\ (P0_4)_6\ (OH)_2$

Le Phosphate Tricalcique Béta (β-TCP) :

- $Ca_3\ (P04)_2$

Bio Verre

« un verre est un solide non cristallin présentant le phénomène de transition vitreuse » (Zarzycki 1982)

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Review

Reprint of: Review of bioactive glass: From Hench to hybrids

Julian R. Jones *

Department of Materials, Imperial College London, South Kensington Campus, London SW7 2AZ, UK

Selected properties of melt-derived Bioglass 45S5 [60,148].

Property	Value
Density	2.7 g cm^{-3}
Network connectivity	2.12
Glass transition temperature	538 °C
Onset of crystallization	677 °C
Thermal expansion coefficient	15.1 × 10^{-6} $°C^{-1}$
Young's modulus (stiffness)	35 MPa

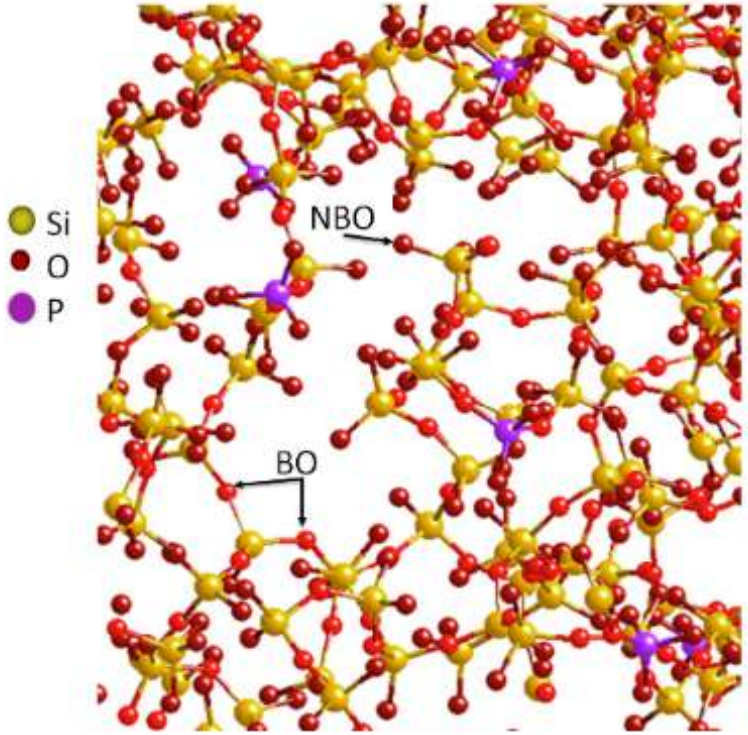

Fig. 10. Section of a model of Bioglass® 45S5, with the Na and Ca ions removed for clarity. NBO – non-bridging oxygen, BO – bridging oxygen. Modified from Cormack et al. [136].

Journal of Non-Crystalline Solids 432 (2016) 2–8

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journal homepage: www.elsevier.com/ locate/ jnoncrysol

Bioglass: 10 milestones from concept to commerce

Larry L. Hench

Department of Biomedical Engineering, Florida Institute of Technology, Melbourne, FL, USA

Table 1
Milestones of science and clinical product development of 45S5 Bioglass.

1971	First publication of bonding of bone to bioactive glasses and glass-ceramics
1981	Discovery of soft connective tissue bonding to 45S5 Bioglass
1981	Toxicology and biocompatibility studies (16 in vitro and in vivo) published to establish safety for FDA clearance of bioglass products
1985	First medical product (Bioglass Ossicular Reconstruction Prosthesis) (MEP) cleared by FDA via the 510 (k) process
1987	Discovery of osteostimulation in use of Bioglass particulate in regeneration of bone
1988	Bioglass Endosseous Ridge Maintenance Implant (ERMI) cleared by FDA via the 510 (k) process
1991	Development of sol–gel processing method for making bioactive gel-glasses extending the bioactive compositional range of bioactivity
1993	Bioglass particulate for use in bone grafting to restore bone loss from periodontal disease in infrabony defects (PerioGlas) cleared by FDA via the 510 (k) process
1996	Use of PerioGlas for bone grafts in tooth extraction sites and alveolar ridge augmentation cleared by FDA *via* the 510 (k) process
2000	FDA clearance for use of NovaBone in general orthopedic bone grafting in non-load bearing sites
2000	Quantitative comparison of rate of trabecular bone formation in presence of Bioglass granules versus synthetic HA and A/W glass-ceramic
2000	Analysis of use of 45S5 Bioglass ionic dissolution products to control osteoblast cell cycles
2001	Gene expression profiling of 45S5 Bioglass ionic dissolution products to enhance osteogenesis
2004	FDA clearance of 45S5 particulate for use in dentinal hypersensitivity treatment (NovaMin)

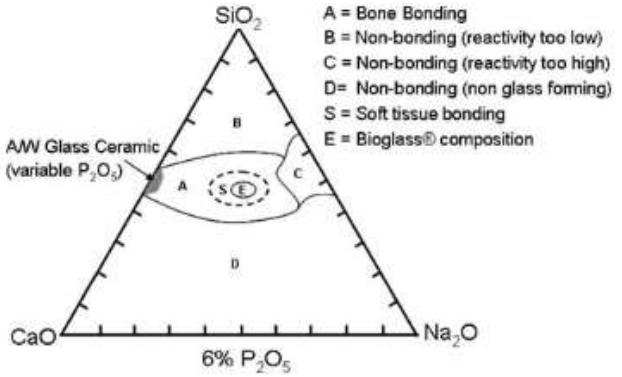


Fig. 1 Compositional diagram for bone-bonding. Note regions A, B, C, D. Region S is a region of Class A bioactivity where bioactive glasses bond to both bone and soft tissues and are gene activating

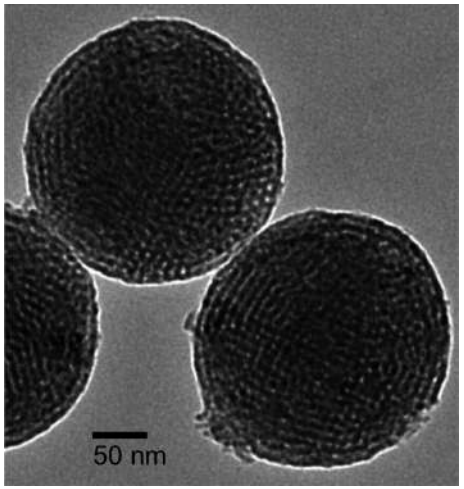
J Mater Sci: Mater Med (2006) 17:967–978
DOI 10.1007/s10856-006-0432-z

The story of Bioglass®

Larry L. Hench

Différents Bio Verres

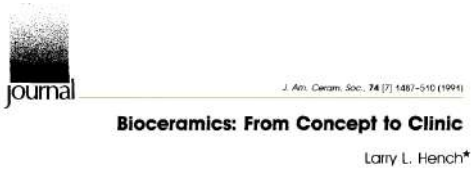
- Taille des particules: Micro à nanométriques
- Compositions : avec Argent, Potassium, Magnésium, Strontium…
- Nano ou meso porosité
- +/- Cristallisés



Transmission electron microscope image of ordered mesoporous silica particles. Courtesy of Lijun Ji, Yangzhou University, China.

Table IV. Composition of Bioactive Glasses and Glass-Ceramics (wt%)

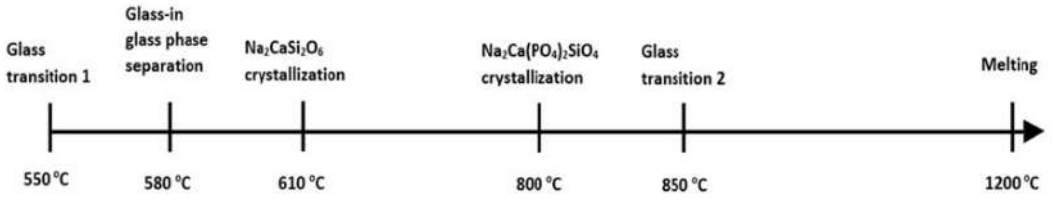
Component	45S5 Bioglass®	45S5.4F Bioglass®	45B15S5 Bioglass®	52S4.6 Bioglass®	55S4.3 Bioglass®	KGC Ceravital®	KGS Ceravital®	KGy213 Ceravital®	A/W glass-ceramic	MB glass-ceramic	S45P7
SiO_2	45	45	30	52	55	46.2	46	38	34.2	19–52	45
P_2O_5	6	6	6	6	6				16.3	4–24	7
CaO	24.5	14.7	24.5	21	19.5	20.2	33	31	44.9	9–3	22
$Ca(PO_3)_2$						25.5	16	13.5			
CaF_2		9.8							0.5		
MgO						2.9			4.6	5–15	
MgF_2											
Na_2O	24.5	24.5	24.5	21	19.5	4.8	5	4		3–5	24
K_2O						0.4				3–5	
Al_2O_3								7		12–33	
B_2O_3			15								2
Ta_2O_5/TiO_2								6.5			
Structure	Glass and glass-ceramic	Glass	Glass	Glass		Glass-ceramic	Glass-ceramic	Glass-ceramic	Glass-ceramic	Glass-ceramic	



Synthèse

Fusion : Mélange de matériaux brut inorganiques chauffés entre 1300 et 1600 °C puis refroidi sans permettre la cristallisation

Transformations structurales des bio verres :



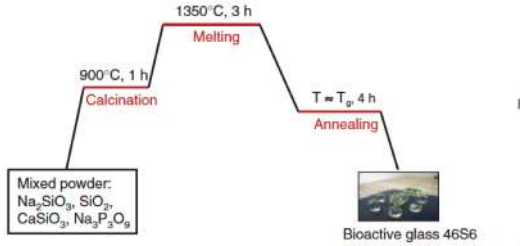
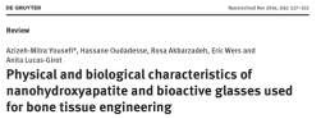


Figure 14 The thermal process for the synthesis of bioactive glass 46S6. Modified from Ref. [138].

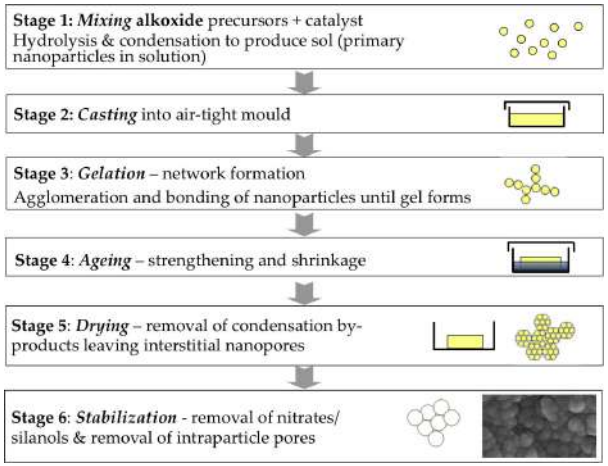


Review

Azizeh-Mitra Yousefi*, Hassane Oudadesse, Rosa Akbarzadeh, Eric Wers and Anita Lucas-Girot

Physical and biological characteristics of nanohydroxyapatite and bioactive glasses used for bone tissue engineering

Sol-gel : D'une solution qui gélifie en polymérisant en milieu aqueux. Puis le gel est séché et recuit



A flow chart of the acid-catalysed sol–gel process of synthesis of a bioactive glass with schematics of the evolution of the gel and its nanoporosity.

Interface osseuse

- Une couche d'apatite carbonatée (HCA) bio-active se forme au contact des tissus biologiques à l'interface.
- La phase HCA qui se forme sur les implants bioactifs est chimiquement et structurellement équivalente à la phase minérale de l'os.
- C'est cette équivalence qui est responsable de la liaison interfaciale.

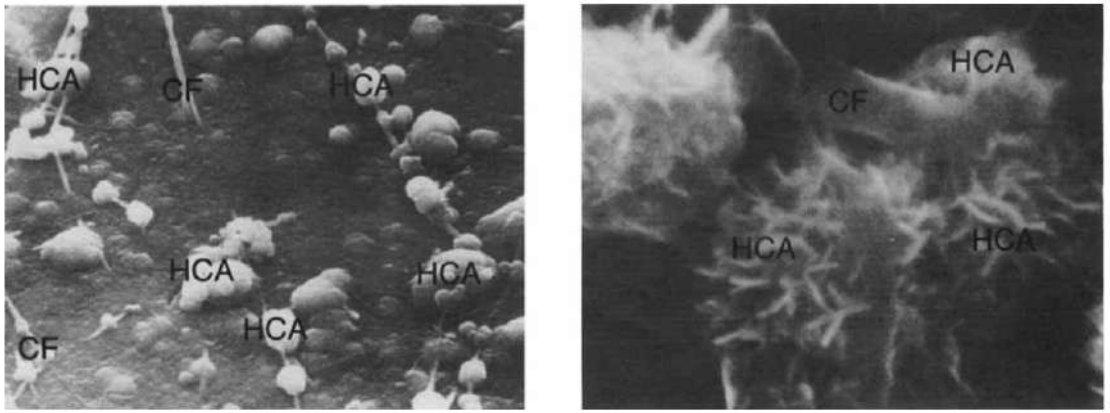
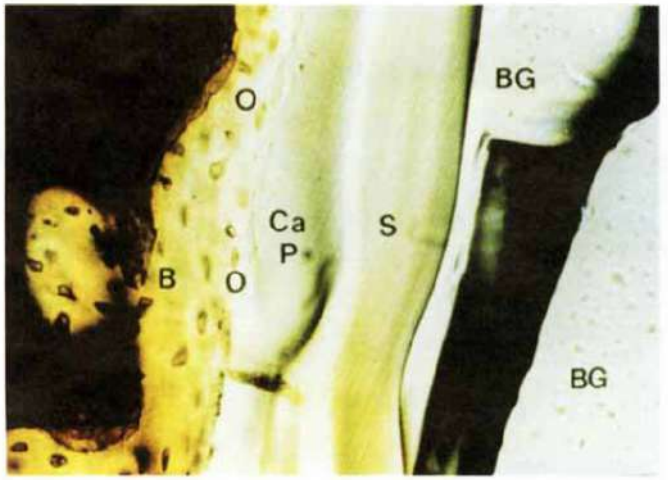
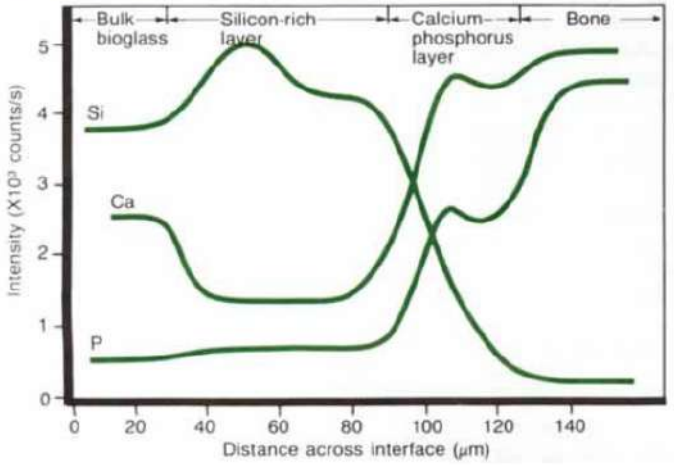


Fig. 9. (a) SEM micrograph of collagen fibrils incorporated within the HCA layer growing on a 45S5 Bioglass® substrate in vitro. (b) Close-up (~11300×) of the HCA crystals bonding to a collagen fibril. (Photographs courtesy of C. Pantano.)





(a) Optical micrograph of a (BG) 4585 Bioglass@ implant bonded to (B) rat bone after 1 year showing (0) osteocytes or bone cells in conjunction with the (Ca-P) HCA layer formed on top of the (S) silica gel (from Ref 44) (b) Electron microprobe analysis across the implant-bone interface shown in (a) (electron microprobe at 20 kV, 100 nA (speciman current), -1-μm beam diameter, and 20 μm/(min in) scan rate

Journal of Non-Crystalline Solids
Contents lists available at ScienceDirect
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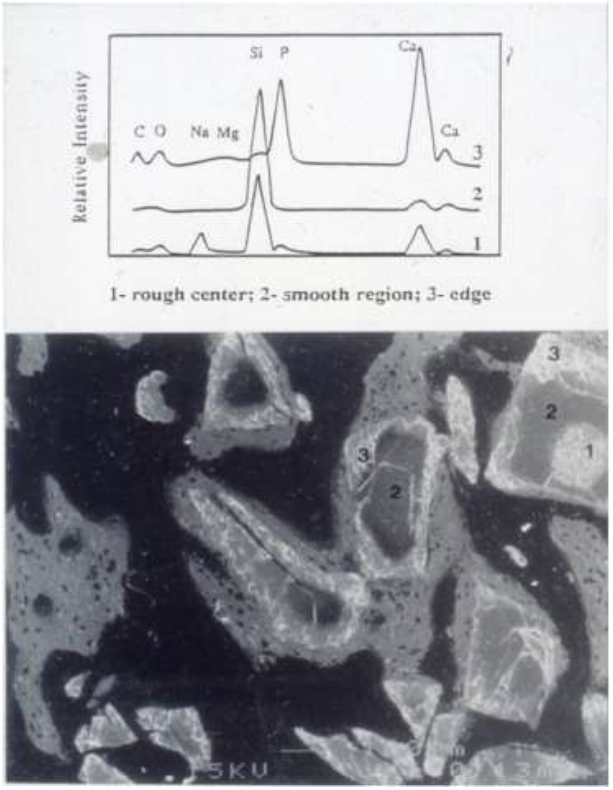
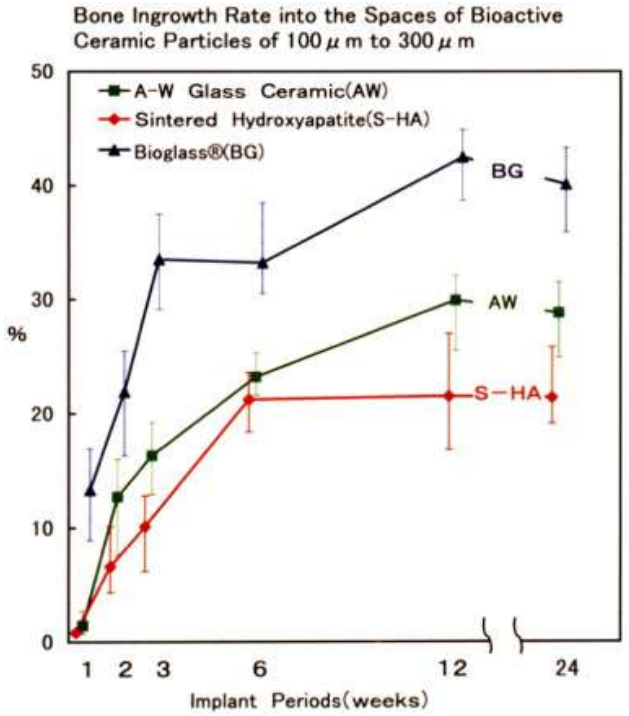
Bioglass: 10 milestones from concept to commerce

Larry L. Hench

Régénération osseuse avec les Bio Verre

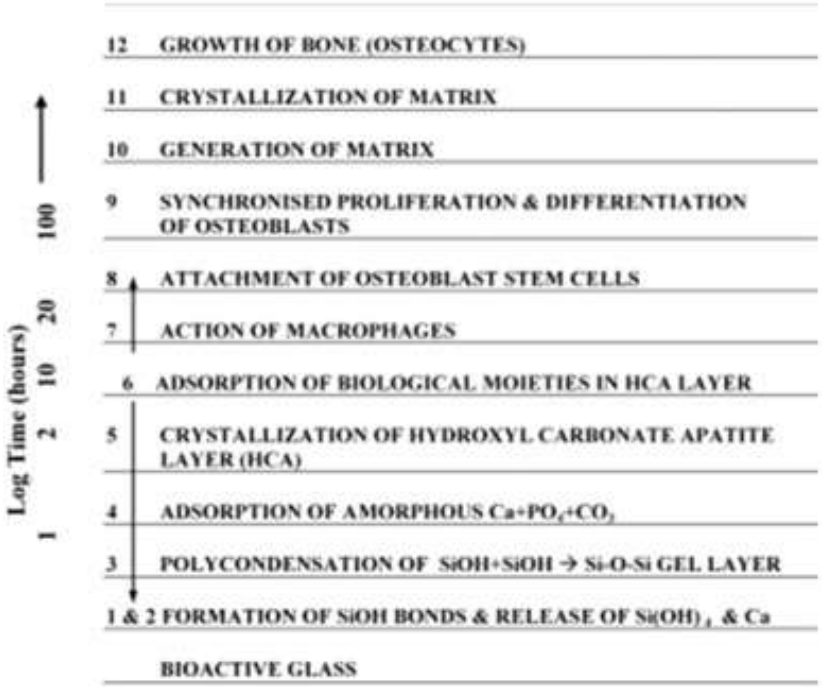


Scanning electron micrograph (SEM) of new bone growing around and connecting 45S5 Bioglass particles to form a regenerated trabecular bone structure. Upper figure is SEM-EDS analysis of the composition gradients of the Bioglass particles due to ion exchange reactions that lead to growth of a biologically active hydroxyl-carbonate-apatite (HCA) layer that is rich is in Ca, region #3.

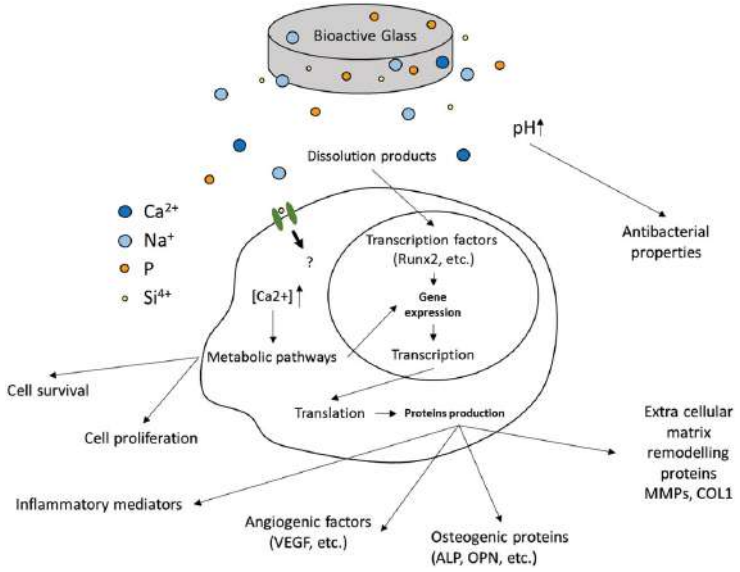


Rapid regeneration of new bone from Class A Bioglass versus Class B bioactive A/W and HA particles in Oonishi critical size defect rabbit condyle model. Note rapid growth of new bone within 4weeks in the presence of Bioglass particles and eventual greater amount of bone regenerated within the critical size defect.

Effets biologiques des Bioverres



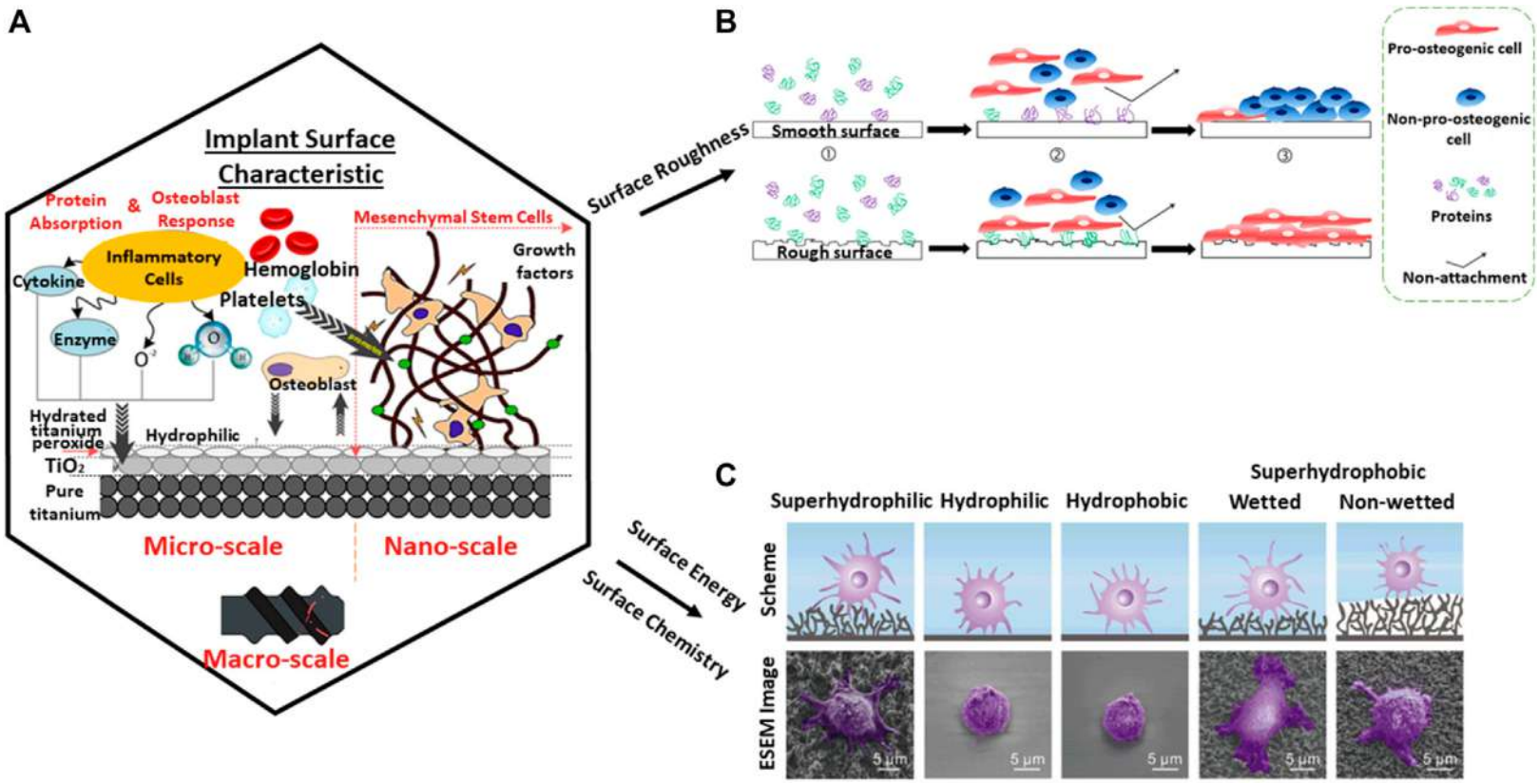
Twelve stages of reaction to form new bone (osteogenesis) bonded to a 45S5 bioactive glass surface. Stages 1–5 are controlled by the kinetics of surface reactions. Note the logarithmic time axis on the left. The early stages of glass surface reactions (Stages 1–4) occur within minutes to a few hours on the most bioactive glass surfaces with compositions ranging from 45 to 52% silica.



REVIEW
Bone Regeneration
ADVANCED HEALTHCARE MATERIALS
www.advhealthmat.de

Optimized Bioactive Glass: The Quest for the Bony Graft

Henri Granel, Cédric Bossard, Lisa Nucke, Fabien Wauquier, Gael Y. Rochefort, Jérôme Guicheux, Edouard Jallot, Jonathan Lao, and Yohann Wittrant*

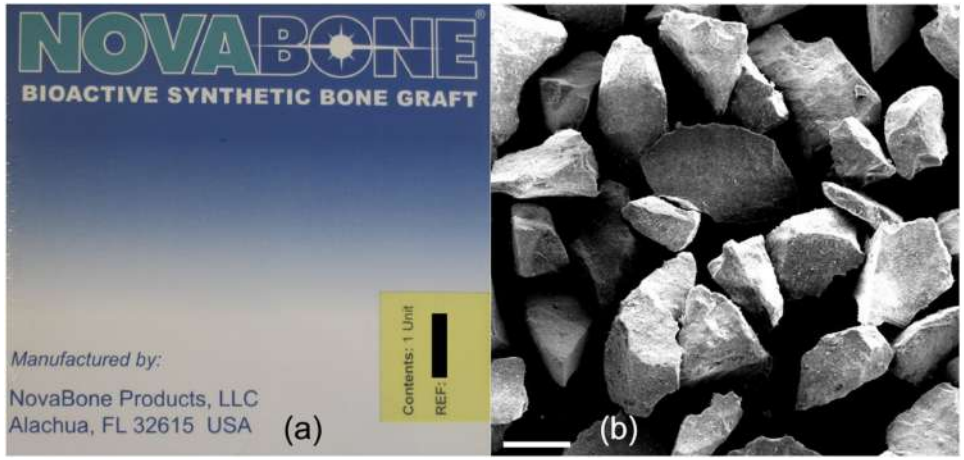


Protein adsorption on the substrate from (A) nano-to-macro level which is dependent on several factors. (B) Surface roughness (Stich et al., 2021). (C) Surface chemistry and surface energy (Meng et al., 2017). Diagram adapted and adjusted from Alipal et al. (2021).

Granules

NOVABONE

Proven to Signal, Recruit, Proliferate, and Differentiate.



A) Packaging of NovaBone (45S5 Bioglass) powder for orthopedic applications and (B) scanning electron micrograph of NovaBone particles. Modified with permission from Jones (2013).

NORAKER®

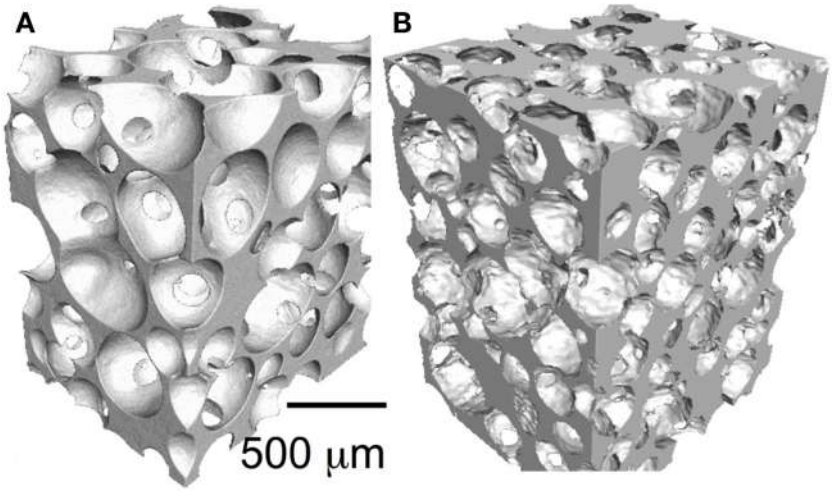
THE BIOGLASS® COMPANY

IBS

NovaBone Putty is a versatile bone graft substitute that is ready to use out of the package with exceptional handling characteristics that will save time and improve placement.

Glassbone injectable putty is composed of 45S5 bioactive glass and a polymer. This composite technology allows it to be very easily malleable and applicable in complex defects. It is sold directly in the syringe, ready to use.

Mousses de bio verres



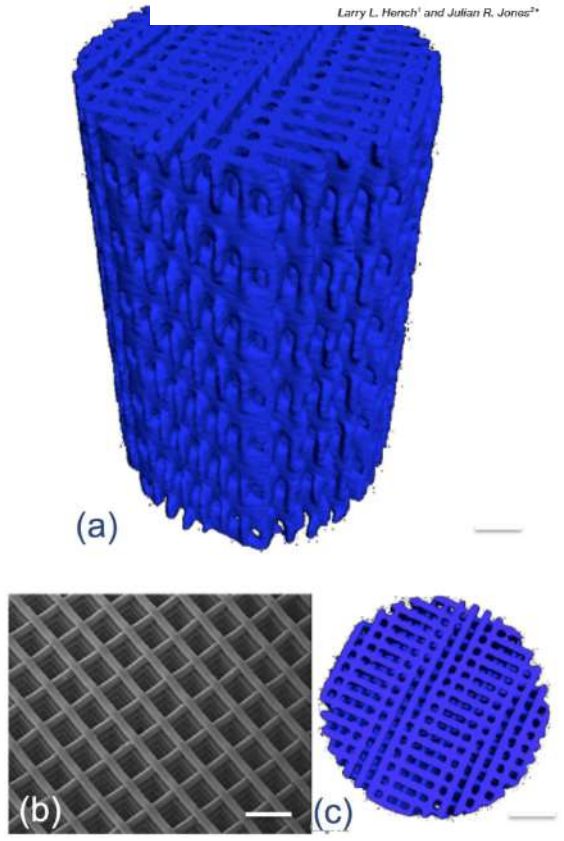
X-ray microtomography images of bioactive glass scaffolds (A) sol–gel foam and (B) melt-derived gel-cast foam. Modified with permission from Jones (2013)

Cependant, les échafaudages en verre bioactif restent fragiles et ne conviennent donc pas à toutes les applications de greffe, comme les sites soumis à des charges cycliques.

frontiers in Bioengineering and Biotechnology
REVIEW

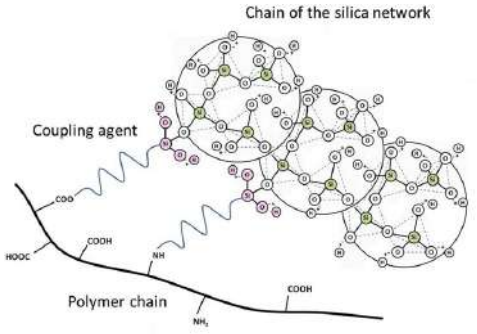
Bioactive Glasses: Frontiers and Challenges

Larry L. Hench[1] and Julian R. Jones[2]*

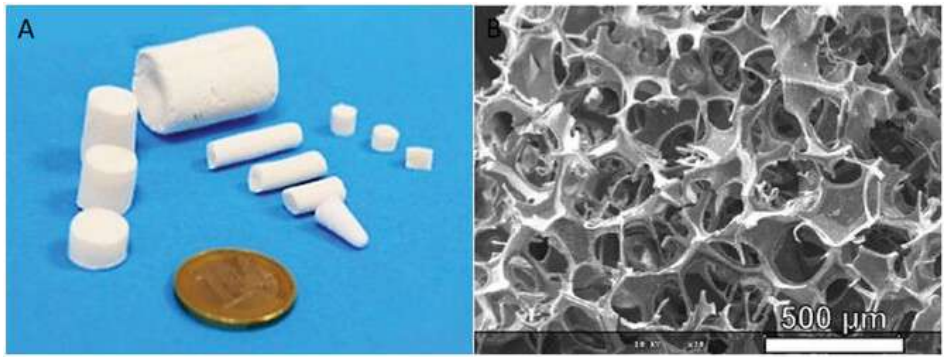


X-ray microtomography image of 3-D printed bioactive glass scaffolds. Modified with permission from Jones (2013).

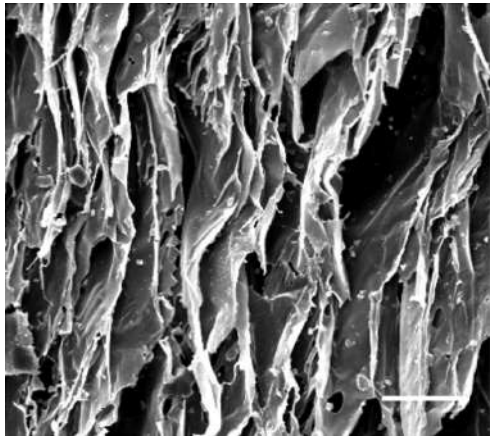
Matériaux hybrides organiques/inorganiques



Granel H. Adv. Healthcare Mater.2019, 8, 1801542



Gelatin/BAG hybrid scaffolds: a) under different shapes; b) observed in scanning electron microscopy. Copyright 2016, The Royal Society of Chemistry (J. Lao, X. Dieudonné, F. Fayon, V. Montouillout, E. Jallot, J. Mater. Chem. B2016, 4, 2486)



An SEM image of a PLLA foam (94% porosity) containing 15vol.% Bioglass 45S5 particles produced by the thermally induced phase separation (TIPS) process. Modified from Blaker et al. 2005 Scale bar is 100µm.

Composites

A review on mechanical and In-vitro studies of polymer reinforced bioactive glass-scaffolds and their fabrication techniques

By: Jain, S (Jain, Satish) [1] ; Gujjala, R (Gujjala, Raghavendra) [1] ; Azeem, PA (Azeem, P. Abdul) [2] ; Ojha, S (Ojha, Shakuntala) [3] ; Samudrala, RK (Samudrala, Raj Kumar) [2]

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CERAMICS INTERNATIONAL

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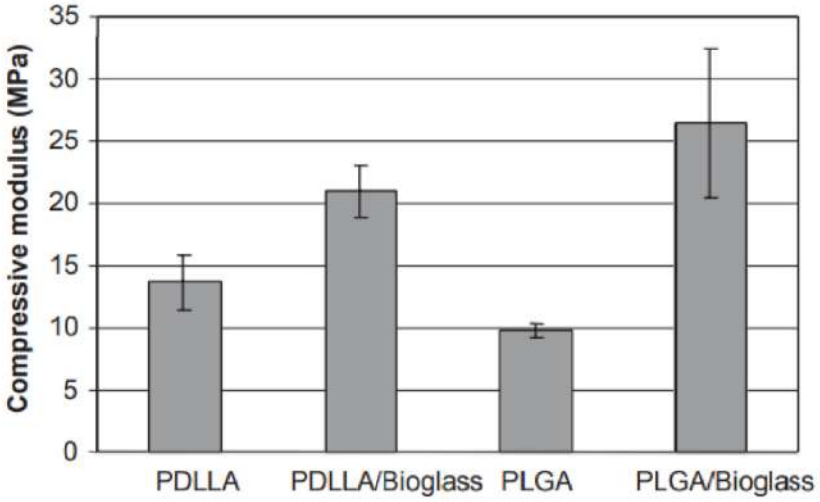
DOI: 10.1016/j.ceramint.2021.11.206
Published: MAR 1 2022
Indexed: 2022-03-02
Document Type: Review

Table 4
Mechanical characteristics of PLAGA, PCL, and P[3HB] based bioactive glass composite.

Scaffold	Fabrication Technique	Average Porosity	Mechanical Properties (MPa)	Reference
PLAGA	Traditional solvent casting	31%	E: 26.48 ± 3.47; Compressive Strength: 0.53± 0.07	[130]
PLAGA-BG	Traditional solvent casting	43%	E: 51.34 ± 6.08; Compressive Strength: 0.42± 0.05	[130]
PLAGA-BG	TIPS	>90%	E: 8-23	[131]
PCL-BG	Particle Leaching/Freeze Extraction	~ 86%	Compressive Strength: 0.04–0.12; Modulus: 0.45–1.15	[138]
PCL-BG	Solid-Liquid Phase separation	88–92%	Compressive Strength: 0.092–0.214; Modulus: 0.132–0.251	[139]
PCL-BG	Melt extrusion based Additive manufacturing	~ 75	Compressive Young's modulus: 48.35 ± 2.57	[140]
PCL-n SiO_2–CaO	Thermal injection Molding	–	Tensile Strength: 19–21.5; Elastic Modulus: 851 ± 43	[141]
PCL- SiO_2–CaO–P_2O_5	Solvent casting	–	Tensile strength = 7–14; Elastic Modulus: 140-170	[142]
PCL-50P_2O_5+50CaO	Compression molding	–	Flexural strength: 25–30; Modulus (GPa):0.5–2.4	[143]
P[3HB]-BG	Solvent Casting	–	Modulus: 800–1100; Hardness: 120-180	[144]



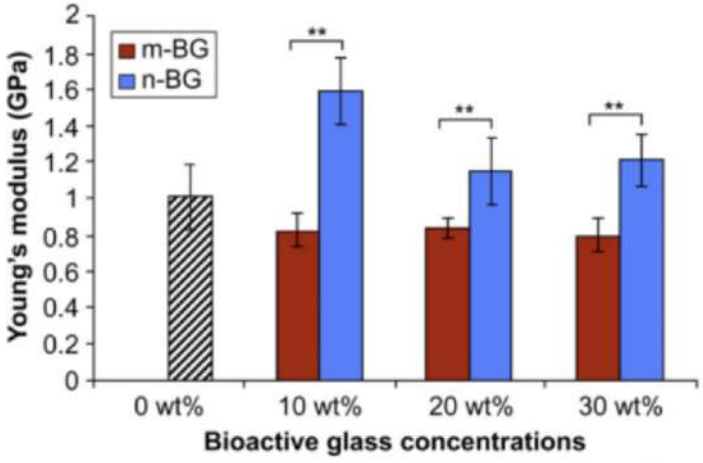
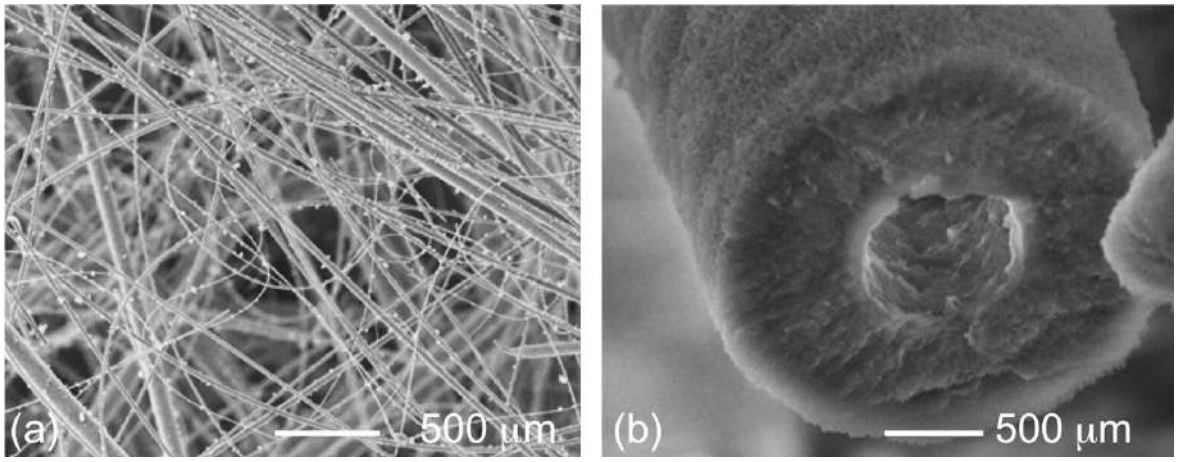


Fig. 5. variation in modulus as change in m-BG and n-BG content in P[3HB]/BG composite [156].

Nano fibres



SEM images of Bioglass 45S5 nanofibres produced by the laser spinning method. (a) The as-produced fibres. (b) After 48h in simulated body fluid a fibre has become a tube of HCA. Modified from Quintero et al.


Acta Biomaterialia 23 (2015) S53–S82
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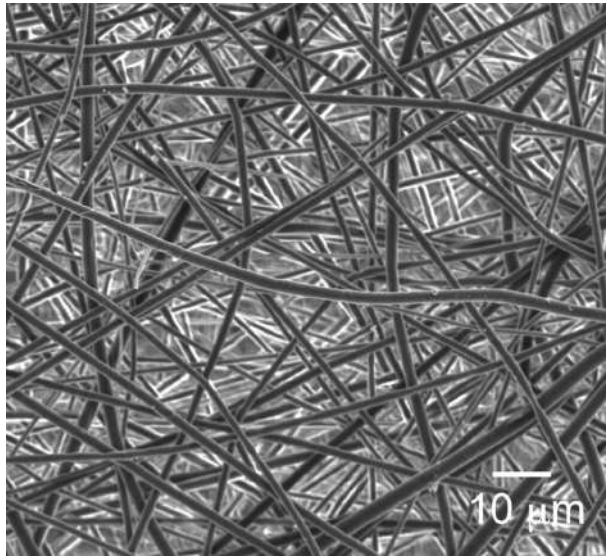
journal homepage: www.elsevier.com/locate/actabiomat

Review

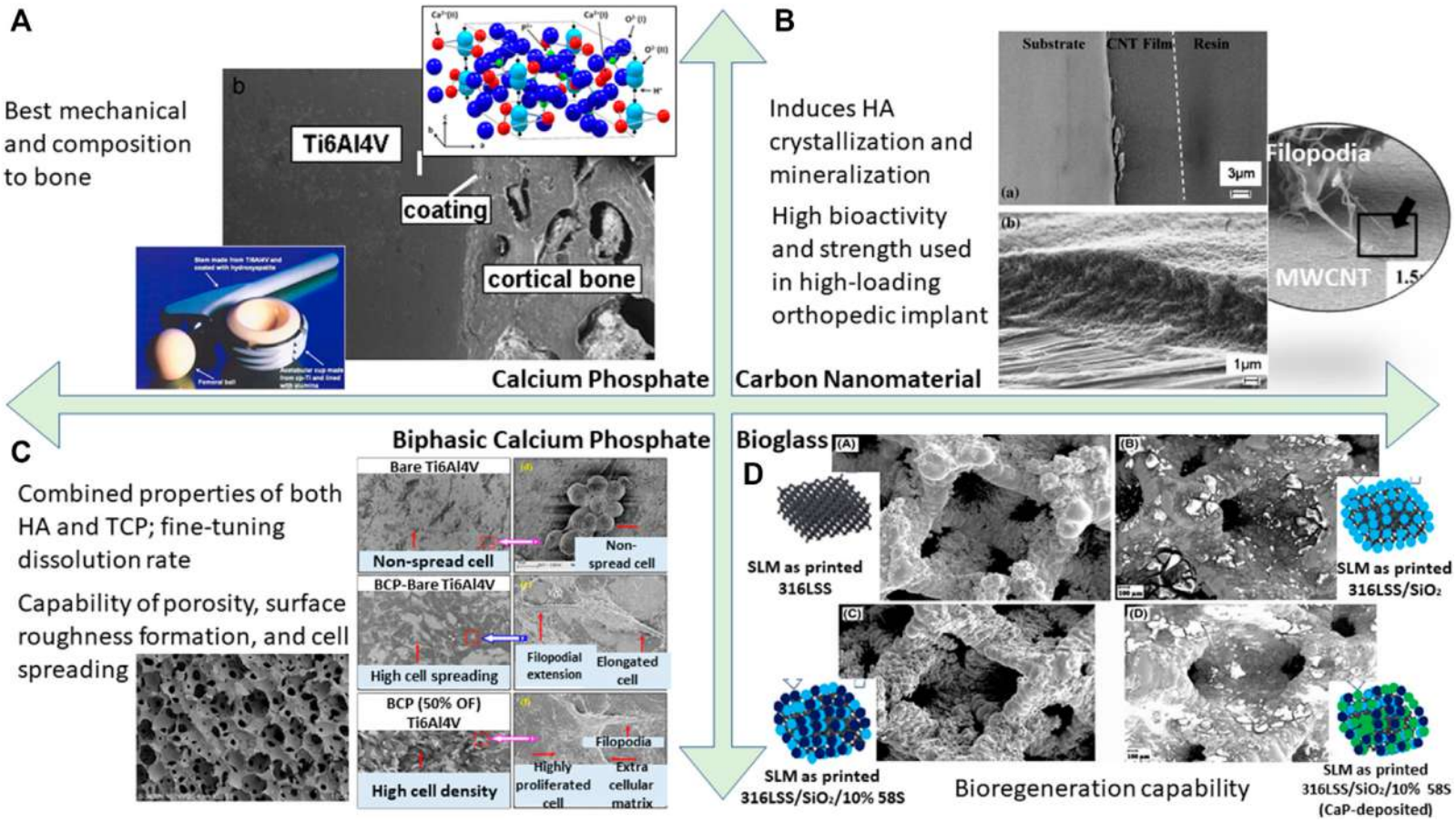
Reprint of: Review of bioactive glass: From Hench to hybrids

Julian R. Jones *



SEM image of an electrospun sol–gel hybrid fiber mat of silica–calcium–PLLA (20wt.% silica). Courtesy of Gowsihan Poologasundarampillai.

Revêtements



A summary of bioactivity assessment conducted on different types of bioactive coating resulting in cell adhesion capability; (A) calcium phosphate (Heimann 2013). (B) Carbon nanomaterial (Li et al., 2011). (C) Biphasic calcium phosphate (Ebrahimi et al., 2017; Behera et al., 2020). (D) Bioglass (Tabia et al., 2021).

Utilisation clinique

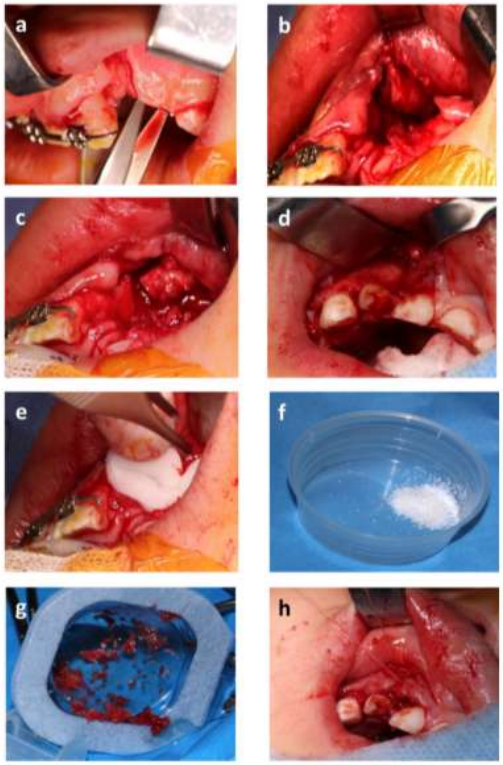
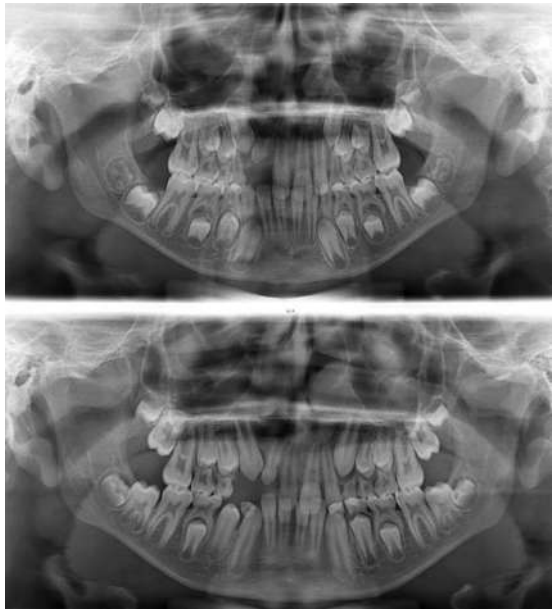


Figure 9: Photographies des étapes de la GOA (d'après la collection personnelle des Drs Audrey Gallucci et Nathalie Degardin, Hôpital La Timone Enfant, AP-HM). (a) Incision de la muqueuse. (b) Lambeau muco-périosté, visualisation du défaut osseux. (c,d) Dissection de la muqueuse nasale. (e) Mise en place du Pangen®. (f) GlassBONE™ pur. (g) GlassBONE™ mélangé au sang du patient. (h) Sutures finales du lambeau muco-périosté après mise en place du GlassBONE™.

20



Dental panoramic view-preoperative (A) and at 1 year (B) showing the evolution of the lateral incisor and the canine through the right alveolar bone graft with GlassBONE™.

Journal of Cranio-Maxillo-Facial Surgery

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Journal of Cranio-Maxillo-Facial Surgery

journal homepage: www.jcmfs.com

Bioactive glass 45S5 ceramic for alveolar cleft reconstruction, about 58 cases*

Nicolas Graillon [a,*], Nathalie Degardin [b], Jean Marc Foletti [c,d], Magali Seiler [e], Marine Alessandrini [f], Audrey Gallucci [a]

5. Conclusion

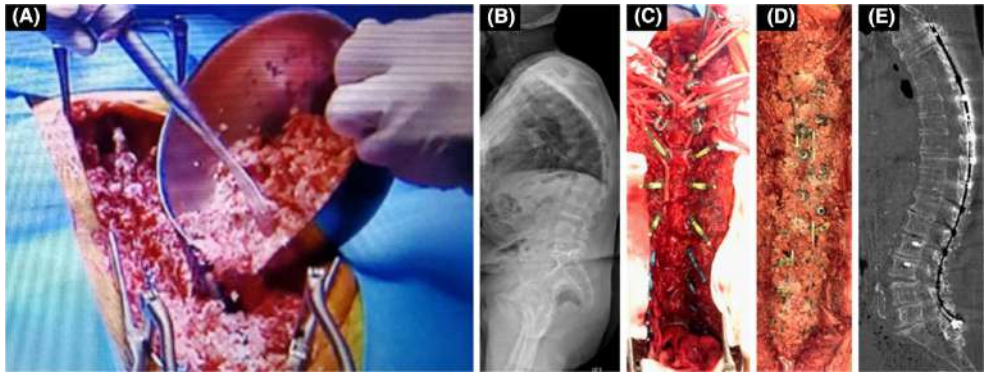
Alveolar bone grafting using a synthetic bioactive glass bone substitute can be an alternative to iliac crest bone grafting. It simplifies the surgical procedure and outcomes, allows satisfactory mucosal and bone healing, supports tooth eruption, authorizes the performance of the grafting at an earlier stage, and facilitates the acceptability of a late pre-implant transplant because of its simplicity. In case of failure, it does not contraindicate a new grafting using a bone substitute or autologous bone.

European Journal of Orthopaedic Surgery & Traumatology (2019) 29:1623–1629
https://doi.org/10.1007/s00590-019-02477-5

ORIGINAL ARTICLE • SPINE - BIOMATERIALS

Clinical and radiographic evaluation of bioactive glass in posterior cervical and lumbar spinal fusion

Cédric Barrey[1] · Théo Broussolle[1]



Mix of GlassBone with local autologous bone and saline serum place on the decorticated posterior elements of the spine;

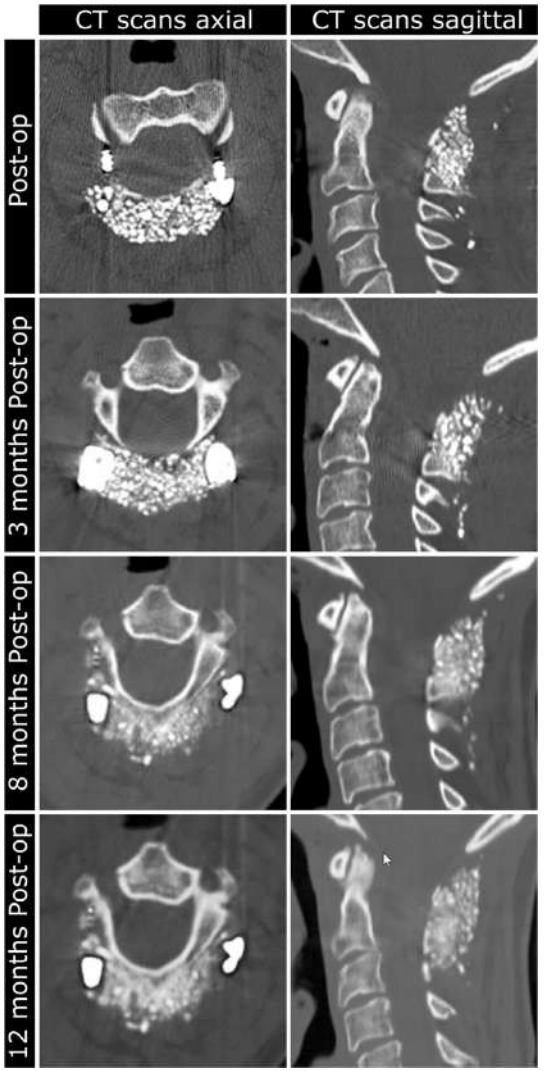


Table 4 Graft consolidation for 29 patients. One patient was excluded for this study (see Table 3)

Graft consolidation	12 m post-op cervical (*n*)	1 y post-op for T-L-S (*n*)
Acquired	2 (100%)	22 (82%)
In progress	0	3 (11%)
Pseudarthrosis	0	2 (7%)
Mediocre	0	0

T-L-S thoraco-lumbar-sacral

Tissus mous

Acta Biomaterialia 13 (2015) 1–15

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Review

Bioactive glasses beyond bone and teeth: Emerging applications in contact with soft tissues

Valentina Miguez-Pacheco[a], Larry L. Hench[b], Aldo R. Boccaccini[a,c,*]

[a] Institute of Biomaterials, University of Erlangen-Nuremberg, 91058 Erlangen, Germany
[b] Department of Biomedical Engineering, Florida Institute of Technology, Melbourne, FL, USA
[c] Department of Materials, Imperial College London, London SW7 2AZ, UK

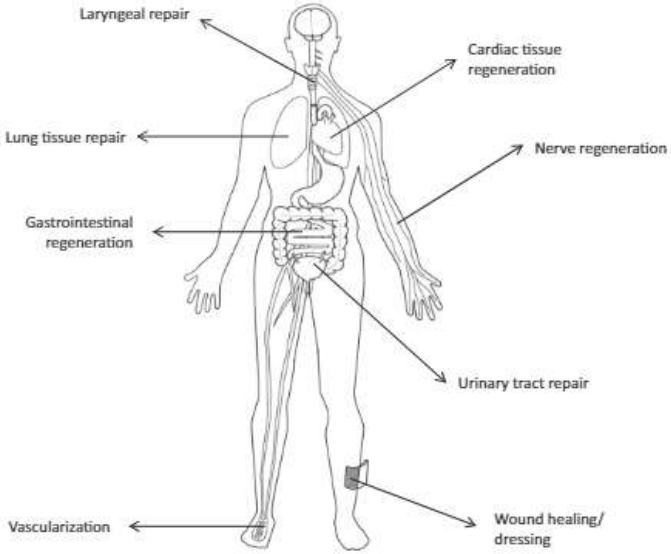
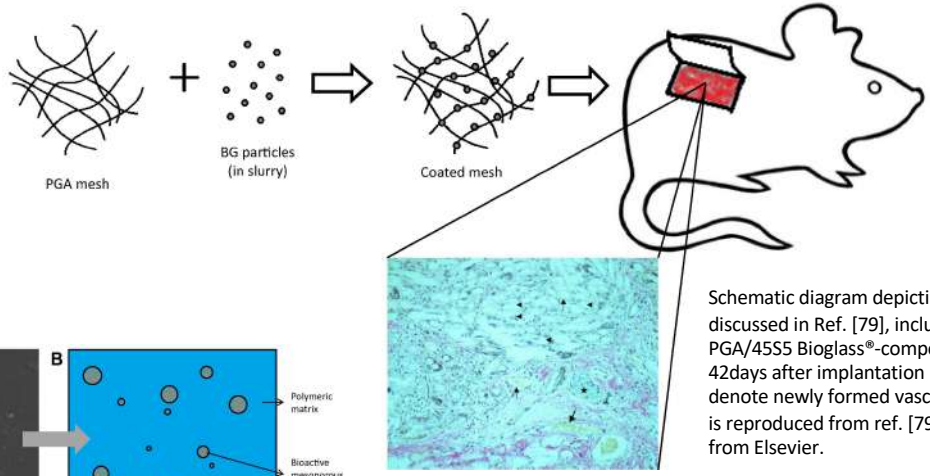
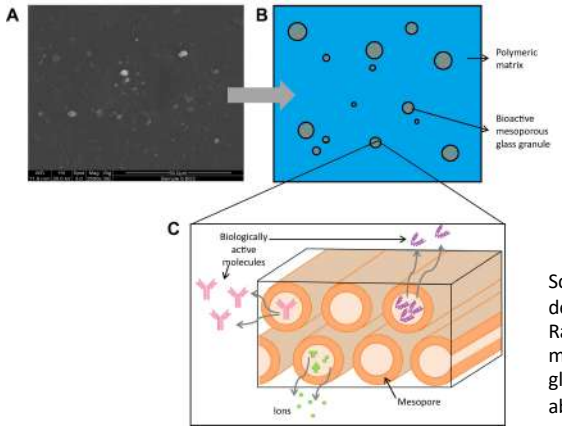


Fig. 1. Schematic diagram indicating emerging BG applications in soft tissue regeneration.



Schematic diagram depicting the experiment discussed in Ref. [79], including the image of PGA/45S5 Bioglass®-composite scaffold 42days after implantation in rat. The arrows denote newly formed vasculature. The image is reproduced from ref. [79] with permission from Elsevier.



Scanning electron microscopy image of a PGS-BG composite developed for cardiac tissue engineering (courtesy of Dr. R. Rai, Erlangen); (b) schematic diagram showing biopolymer matrix incorporating drug-loaded mesoporous bioactive glass particles with (c) dual therapeutic ion and drug delivery ability.

Peau et bio verres

Acta Biomaterialia 13 (2015) 1–15

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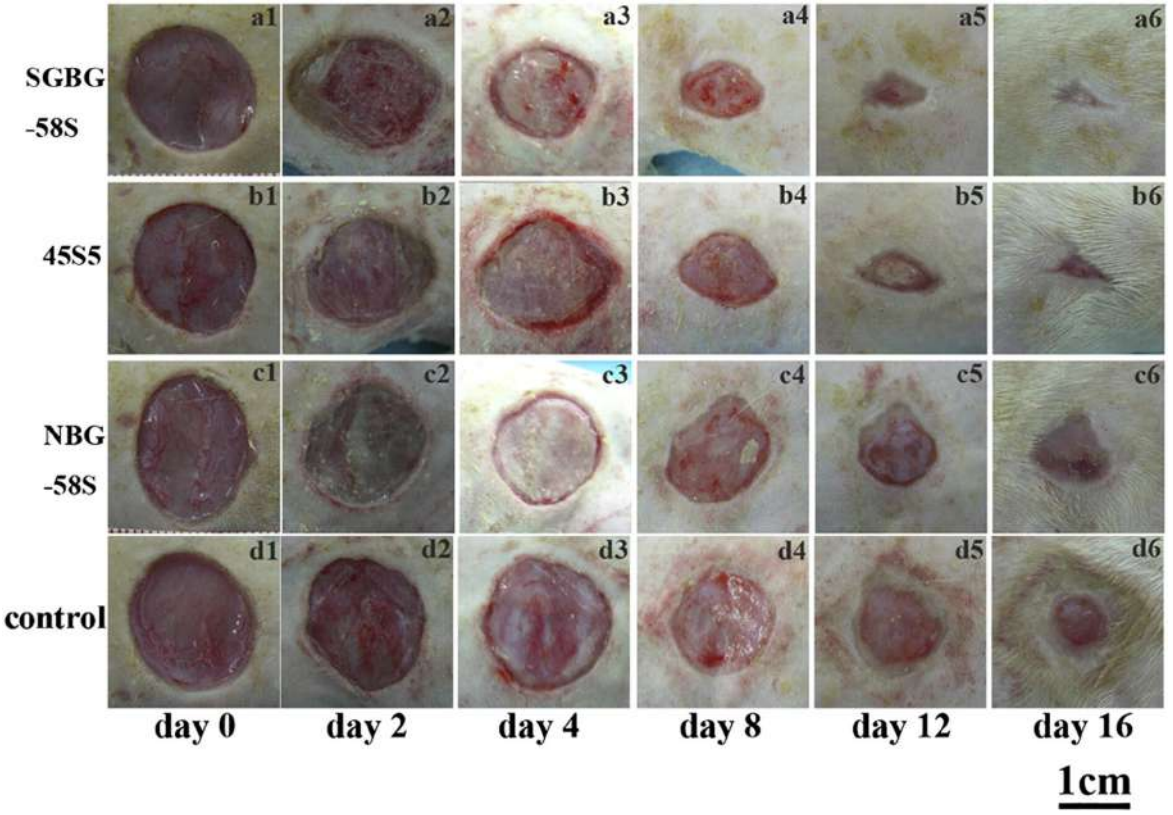
Review

Bioactive glasses beyond bone and teeth: Emerging applications in contact with soft tissues

Valentina Miguez-Pacheco [a], Larry L. Hench [b], Aldo R. Boccaccini [a,c,*]

[a] Institute of Biomaterials, University of Erlangen-Nuremberg, 91058 Erlangen, Germany
[b] Department of Biomedical Engineering, Florida Institute of Technology, Melbourne, FL, USA
[c] Department of Materials, Imperial College London, London SW7 2AZ, UK



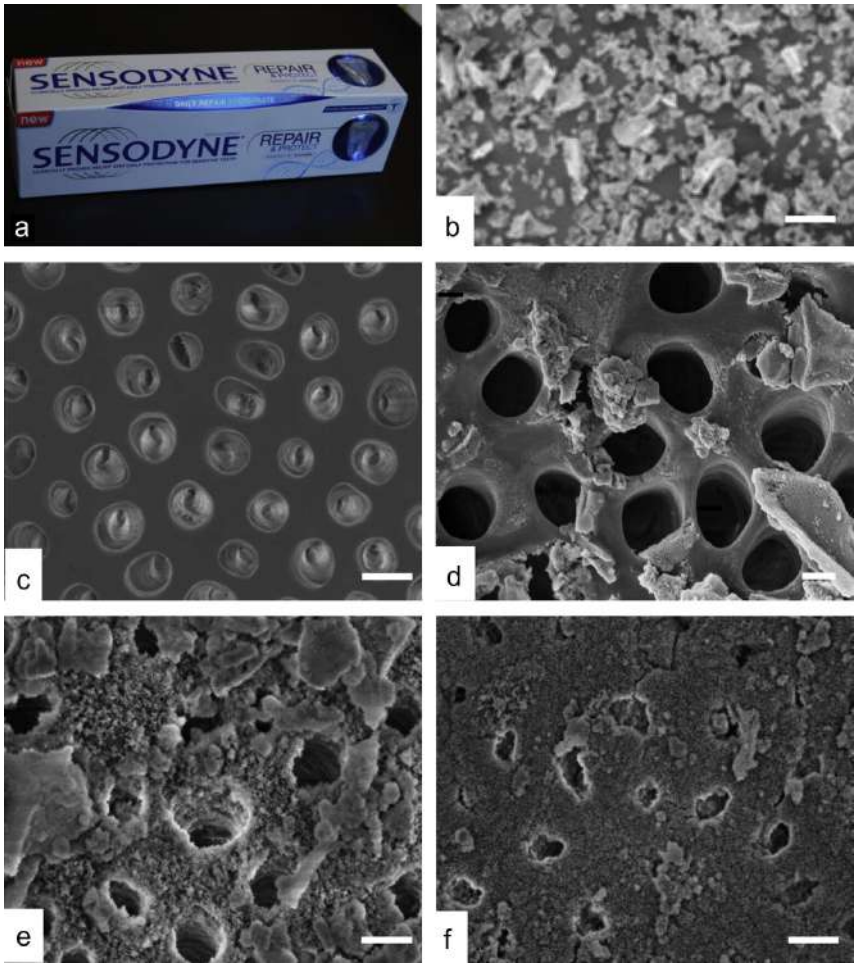
BG treated and untreated wounds from days 0–16 according to Lin et al. [114]. Wounds were treated with different types of BGs, as indicated. It can be seen that SGBG-58S led to the fastest healing rates [114]. Reproduced from ref. [114] by permission of IOP Publishing. All rights reserved.

Lin C, Mao C, Zhang J, Li Y, Chen X. Healing effect of bioactive glass ointmenton full-thickness skin wounds. Biomed Mater 2012;7(4):045017.

Autres

- Dentifrices

Photograph of Sensodyne Repair and Protect toothpaste, which contains NovaMin®, a fine particulate of Bioglass 45S5®. (b) SEM image of NovaMin particles (bar=20µm). (c–f) SEM micrographs of human dentine (bar=1µm): (c) untreated, (d) immediately after application of NovaMin in artificial saliva (AS); (e) 24h after application of NovaMin in AS; (f) 5days after application. SEM images modified from Earl et al.



Conclusion

- Bio verres sont des matériaux intéressant et efficaces pour la régénération tissulaire des tissus minéralisés ou non
- Contrairement aux céramiques cristallines de nombreux ions actifs peuvent être ajoutés
- Bioactifs ++
- Nombreux designs d'échafaudages possibles
- Matériaux fragiles et résorbés rapidement

- → adapté pour certaines applications cliniques :
- →Large arsenal thérapeutique