BIOGRAPHICAL SKETCH

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NAME: **Peter X. Ma, Ph.D.**

eRA COMMONS USER NAME (credential, e.g., agency login): mapxma

POSITION TITLE: **Richard H. Kingery Endowed Collegiate Professor**

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
Tsinghua University, Beijing, China	BS&MS	07/1985	Polymer Chemistry/Materials
Rutgers University, New Brunswick, NJ	PhD	05/1993	Polymer Sci. and Eng.
MIT & Harvard Medical School, Cambridge, MA	Postdoc	08/1996	Biomaterials, Tissue Eng.

A. Personal Statement

Dr. Ma has been conducting research in the areas of biomaterials, controlled biomolecule delivery, and tissue engineering and regenerative medicine for 20 years. His laboratory has focused on design of biocompatible and biodegradable polymers to deliver cells and biomolecules for regeneration. Specifically, the Ma lab has developed nanofibrous scaffolds both in porous foam and injectable microsphere forms, developed various novel micro and nano vehicles to highly efficiently deliver proteins, peptides, small molecule drugs, microRNA and DNA. These scaffolds and delivery systems are focused on regulating gene/protein expression of cells, their phenotype and biological function for treatment of diseases or facilitation of tissue regeneration. He has substantial expertise and experience in evaluating these scaffolds and delivery systems *in vitro* and using animal models. Following are five articles on biomimetic scaffolds, micro/nano carriers for biomolecules and cells, demonstrating his expertise and experience in the subject area.

1) M Dang, AJ Koh, X Jin, LK McCauley and **PX Ma**. Local pulsatile PTH delivery regenerates bone defect via enhanced bone remodeling in a cell-free scaffold. ***Biomaterials 2017***, 114:1-9. PMCID: PMC5125900. *Editors' Choice:* ***Science Translational Medicine*** 23 Nov 2016: Vol. 8, Issue 366, pp. 366ec189 DOI: 10.1126/scitranslmed.aal2797.
2) G Feng, Z Zhang, M Dang, X Zhang, Y Doleyres, Y Song, D Chen, **PX Ma**. Injectable nanofibrous spongy microspheres for NR4A1 plasmid DNA transfection to reverse fibrotic degeneration and support disc regeneration. ***Biomaterials*** **2017**, 131:86-97. PMCID: PMC5448136.
3) X Zhang, Yan Li, YE Chen, J Chen and **PX Ma**. Cell-free 3D scaffold with two-stage delivery of miRNA-26a to regenerate critical sized bone defects. ***Nature Communications 2016,*** 7: Article 10376. PMCID: PMC4735608.
4) Liu X, Jin X, **Ma PX**. Nanofibrous hollow microspheres self-assembled from star-shaped polymers as injectable cell carriers for knee repair. ***Nature Materials*** **2011**;10:398-406. PMCID:PMC3080435.
5) **PX Ma**. Biomimetic Materials for Tissue Engineering, ***Advanced Drug Delivery Reviews 2008***, 60(2): 184-198. PMCID: PMC2271038.

B. Positions and Honors

B1. Professional Positions

1989-1992 **Rutgers University**, New Brunswick, NJ. *Research Assistant*
Jan.-Jun.1993 **Hydromer Inc**. Somerville, NJ. *Research Scientist*
1993 - 1996 **MIT & Harvard Med School,** Cambridge, MA. *Postdoc Associate*
1996 - present **The University of Michigan**, Ann Arbor, MI, *Professor*
Departments of Biologic and Materials Sciences, Biomedical Engineering, Macromolecular Science and Engineering, Materials Science and Engineering
1996 – 2001 *Assistant Professor*
2002 – 2006 *Associate Professor (with tenure)*
2005 – present *Director, Biomaterials Graduate Program*
2007 – present *Professor (with tenure)*

2009 – present *Richard H. Kingery Endowed Collegiate Professor*
Interdisciplinary Center Memberships: *Cardiovascular Center, Center for Organogenesis, Center for Craniofacial Regeneration, Oral Health Science Ph.D. Program, Tissue Engineering Training Program, Cellular Biotechnology Training Program, etc.*

B2. Honors, Awards and Activities (Selected)

- Outstanding Undergraduate Student, Tsinghua University
- Outstanding Graduate Student, Tsinghua University
- Graduate School Excellence Fellow, Rutgers University
- The NOVARTIS Award (with J.M. Pollok et al.), 1997
- Whitaker Foundation Biomedical Engineering Young Investigator Award, 1999
- DuPont Young Professor, 2000
- Featured as one of the five Biomedical Engineering Laboratories by The Whitaker Foundation, 2005
- Fellow, American Institute for Medical and Biological Engineering (AIMBE), 2006
- Honorary Professor, Tsinghua University, Beijing, China, 2008
- Honorary Professor, Zhejiang University Medical School, Hangzhou, China, 2008
- Richard H. Kingery Endowed Collegiate Professor, University of Michigan School of Dentistry, 2009
- Honorary Professor, Xi'an Jiaotong University, Xi'an, China, 2010
- Top 100 Materials Scientists in the World (2000-2010), Thomson Reuters, 2011
- Honorary Member, Omicron Kappa Upsilon (OKU) Dental Honor Society, 2012
- Fellow of Biomaterials Science and Engineering (FBSE), International Union of Societies of Biomaterials Science and Engineering, 2012
- Who's Who in Engineering Higher Education, Who's Who in Dentistry Higher Education, 2012
- Clemson Award for Contributions to the Literature, Society For Biomaterials, 2013
- Distinguished Scientist (Isaac Schour) Award, International Association for Dental Research, 2013
- Fellow, American Association for the Advancement of Science (AAAS), 2013
- Fellow, Materials Research Society (MRS), 2015
- Reviewing articles for more than 80 journals (9 Editorial Boards)
- Reviewing grant proposals for NIH (CMT, BMBI, SBSR, ODCS, BST, BCMB, Challenge Grants, and various special emphasis panels), DOD (USAMRMC), NSF, Department of Veterans Affairs, U.S. Army Corps of Engineers, MacArthur Fellowships, US Civilian Research & Development Foundation, ACS Petroleum Research Fund, MIT Sea Grant College Program, Natural Sciences and Engineering Research Council of Canada, The Canada Foundation for Innovation, European Commission, Wellcome Trust Grants (UK), Swiss National Science Foundation, Dutch Technology Foundation, Foundation for Polish Science, Israel Science Foundation, Austrian Science Fund, NSF of China, Chang Jiang Scholars Program of the Ministry of Education of China, Research Grants Council of Hong Kong, Hong Kong University Grants Committee, Singapore Biomedical Research Council, Singapore National Research Foundation, Singapore Science & Engineering Council, National Research Foundation of Korea etc.
- Published 4 books on biomaterials and regeneration.
- Chaired 56 symposiums and conference sessions
- Served on 41 symposium and conference organization committees
- Delivered 272 plenary/keynote/invited lectures

C. Contributions to Science - Published 261 full-length articles with 25,735 total citations (h-index: 76)

C1. Biomimetic Composite Scaffolds and Mineralized Tissue Regeneration

When Dr. Ma started his independent career at the University of Michigan, one of the major challenges in bone tissue engineering was the lack of a good scaffold. To tackle this challenge, Dr. Ma's group developed a novel solid-liquid phase-separation technique to create highly porous, mechanically strong and osteoconductive composite scaffolds [a]. To more efficiently utilize the osteoconductivity of bioceramics, the Ma lab developed a method to grow bone-like apatite on the pore surface of polymer scaffolds in a simulated body fluid (SBF) [b, c]. University of Michigan received two patents for these technologies. He demonstrated that the incorporation of bone-like mineral enhanced protein adsorption and suppressed apoptosis of osteoblasts, facilitating bone regeneration, revealing the mechanistic advantages of biomimetic composite scaffolds [d]. His group further developed an electrodeposition technique to tailor crystal structure of calcium phosphate on nanofibrous scaffolds, which can control the chemical and morphological structures of the calcium phosphate.

a. Zhang R, **Ma PX**. Poly(alpha-hydroxyl acids)/hydroxyapatite porous composites for bone tissue engineering. I. Preparation and morphology. ***J Biomed Mater Res*** **1999**;44:446-55. **Cited 933 times.**
b. Zhang R, **Ma PX**. Porous poly(L-lactic acid)/apatite composites created by biomimetic process. ***J Biomed Mater Res*** **1999**;45:285-93. **Cited 516 times.**

c. Wei G, **Ma PX**. Structure and properties of nano-hydroxyapatite/polymer composite scaffolds for bone tissue engineering. ***Biomaterials*** **2004**;25:4749-57. **Cited 1077 times.**
d. Woo KM, Seo J, Zhang R, **Ma PX**. Suppression of apoptosis by enhanced protein adsorption on polymer/hydroxyapatite composite scaffolds. ***Biomaterials*** **2007**;28:2622-30. PMCID:PMC1934407. **Cited 188 times.**

C2. Invention of Phase-Separation Technique for ECM-mimicking Nanofibrous Scaffold Fabrication

While scaffolds were found to play a critical role in the quality of the engineered tissues, there was no clear direction to improve the quality of the scaffolds. The Ma lab took a biomimetic approach to create extracellular matrix-mimicking nanofibrous scaffolding materials. A novel liquid-liquid phase separation technique was developed in the Ma lab, which was able to create nanofibrous scaffolds from biodegradable polymers [a, b]. These scaffolds overcame the concern over potential immune rejection and disease transmission problems associated with natural extracellular matrix-derived scaffolds. University of Michigan received a few US patents on the nanofibrous scaffolds. As the field moving forward, patient-specific anatomical shape and more precisely controlled pore structure of the highly porous scaffolds became new challenges in the field of tissue engineering. The Ma lab developed a templating method to create precisely controlled spherical pore network in a tissue-engineering scaffold [c], which also received a US patent. To achieve the patient-specific anatomical shape, the Ma lab developed techniques to integrate medical image-based computer design with phase separation process for scaffold fabrication [d]. This new technology can generate hierarchical scaffold structure on multiple size scales, from anatomical shape, to micro pore network, to nanofibrous matrix feature.

a. **Ma PX**, Zhang R. Synthetic nano-scale fibrous extracellular matrix. ***J Biomed Mater Res*** **1999**;46:60-72. **Cited 1032 times**
b. **PX Ma**. Biomimetic Materials for Tissue Engineering, ***Advanced Drug Delivery Reviews 2008***, 60(2): 184-198. PMCID: PMC2271038. **Cited 1102 times.**
c. Wei G, **Ma PX**. Structure and properties of nano-hydroxyapatite/polymer composite scaffolds for bone tissue engineering. ***Biomaterials*** **2004**;25:4749-57. **Cited 1077 times.**
d. Chen VJ, Smith LA, **Ma PX**. Bone regeneration on computer-designed nano-fibrous scaffolds. ***Biomaterials*** **2006**;27:3973-9. **Cited 194 times.**

C3. Designing Nanofibrous Matrix Microenvironment to Control Stem Cell Fate for Regeneration

Stem cell therapies and regenerative medicine center on various stem cells (adult, embryonic, and induced prupropotent stem cells, etc.). While the tremendous potentials of stem cells in regenerative medicine are well recognized, there remains very limited knowledge on how to control stem cell fate to realize their therapeutic potentials. Initially, the Ma lab demonstrated that the nanofibrous scaffolds selectively enhanced the adsorption of cell adhesion proteins, advantageously support osteoblastic differentiation and bone regeneration [a, b]. The nanofibrous scaffolds were subsequently utilized to control various stem cells (embryonic, amniotic fluid-derived, and mesenchymal stem cells) for bone regeneration. Later, the Ma group found that nanofibrous scaffolds could also be utilized to facilitate chondrogenic and myogenic differentiations of various progenitor cells and stem cells [c, d]. These nanofibrous scaffolds have been widely utilized to regenerate bone, dentin, cartilage, intervertabrite disc, blood vessels, and cardiac tissue.

a. Woo KM, Chen VJ, **Ma PX**. Nano-fibrous scaffolding architecture selectively enhances protein adsorption contributing to cell attachment. ***J Biomed Mater Res A*** **2003**;67:531-7. **Cited 654 times.**
b. Smith LA, **Ma PX**. Nanofibrous scaffolds for tissue engineering. ***Colloids and Surfaces B: Biointerfaces 2004***; 39:125-131. **Cited 596 times.**
c. Hu J, Feng K, Liu X, **Ma PX**. Chondrogenic and osteogenic differentiations of human bone marrow-derived mesenchymal stem cells on a nanofibrous scaffold with designed pore network. ***Biomaterials*** **2009**; 30:5061-7. PMCID:PMC2887482. **Cited 125 times.**
d. Hu J, Sun X, Ma H, Xie C, Chen YE, **Ma PX**. Porous nanofibrous PLLA scaffolds for vascular tissue engineering. ***Biomaterials*** **2010**; 31:7971-7. PMCID:PMC2930107. **Cited: 139 times.**

C4. Novel Injectable Carriers for Cells and Biomolecules for Tissue Regeneration

At the early stage of the Ma lab, Dr. Ma and his students developed hydrogels as injectable scaffolds for tissue engineering [a]. University of Michigan received patents on such inventions. While the nanofibrous porous materials are finding increasing applications in the field of tissue engineering as implantable scaffolds, there is a significant need for injectable form of such scaffold to be used in a minimally invasive manner when small and irregular defects are to be regenerated. The Ma laboratory developed novel star-shaped polymers and the technology for such polymers to assemble into a new type of injectable cell carrier – nanofibrous microspheres, nanofibrous hollow microspheres, and nanofibrous spongy spheres [b, c]. University of Michigan filed several US patent applications on these technologies. These novel nanofibrous cell carriers have been used to

regenerate cartilage, bone, tooth, and other tissues in the Ma lab. They have not only been demonstrated to be successful injectable scaffolds, but also have been shown to be advantageous to regenerate various tissues. For example, excitingly, the regenerated cartilage using the nanofibrous hollow microspheres achieved the same mechanical properties as those of the native cartilage [b]. They have also been functionalized with various peptides to direct stem cell differentiation and tissue regeneration [d].

a. Kuo CK, **Ma PX**. Ionically crosslinked alginate hydrogels as scaffolds for tissue engineering: 1 . Structure, gelation rate and mechanical properties. ***Biomaterials*** **2001**;22:511-21. **Cited 970 times.**
b. Liu X, Jin X, **Ma PX**. Nanofibrous hollow microspheres self-assembled from star-shaped polymers as injectable cell carriers for knee repair. ***Nature Materials*** **2011**;10:398-406. PMCID:PMC3080435. **Cited 231 times.**
c. Zhang Z, Marson R, Ge Z, Glotzer S, **Ma PX**. Simultaneous nano- and micro-scale control of nanofibrous microspheres self-assembled from star-shaped polymers. ***Advanced Materials*** **2015**; 27(26):3947-3952. PMID: 26009995; PMCID: PMC4496277. **Cited 19 times.**
d. Zhang Z, Gupte MJ, Jin X, **Ma PX**. Injectable Peptide Decorated Functional Nanofibrous Hollow Microspheres to Direct Stem Cell Differentiation and Tissue Regeneration. ***Advanced Functional Materials*** **2015**; 25:350-60. PMID: 26069467; PMCID: PMC4459759. **Cited 27 times.**

C5. Biomimetically Programming Microenvironments for Stem Cells to Regenerate Target Tissues

Biological molecules play critical roles in cell proliferation, differentiation, immuno-regulation, and neo tissue regeneration. In regular 2D tissue culture, biomolecules can be easily added to culture medium. However, when a cell-scaffold construct is implanted into a patient (or in an animal model), delivery of biomolecules to the regenerating site becomes a significant challenge. It becomes even more challenging to deliver biomolecules in a controlled fashion (dose and duration). The Ma lab developed technologies to immobilize controlled release nanospheres on the internal pore surface of porous scaffolds and further demonstrated the controlled release of growth factors to enhance tissue regeneration. For this work, his graduate student (Dr. Guobao Wei) received a STAR award from the Society for Biomaterials and his PhD thesis was highlighted as a “shining example” that made important advances in the field (one of the top 12 PhD theses in the US, selected by the journal *Rejuvenation Research* in 2007). The subsequent peer-reviewed publications are also highly cited [a]. The Ma lab recently developed novel polymers that can self-assemble into novel non-viral vectors to simultaneously deliver both genes and drugs to cells [b]. Furthermore, the Ma lab has developed controlled two-stage nucleic acid (RNA or DNA) delivering systems [c] and pulsatile drug delivery systems [d] to direct endogenous stem cells in 3D defined space by a cell-free scaffold to regenerate tissue, dramatically facilitating translation potential of associated tissue engineering products. The Ma lab has also invented microparticles that can trigger the endogenous stem cells to regenerate 3D local tissue. Several US and international patents on these biomimetic delivery/scaffold systems have been filed by the University of Michigan. These cell-free regenerative technologies could overcome many of the translational/regulatory challenges facing the field of tissue engineering products.

a. Wei G, Jin Q, Giannobile WV, **Ma PX**. The enhancement of osteogenesis by nano-fibrous scaffolds incorporating rhBMP-7 nanospheres. ***Biomaterials*** **2007**;28:2087-96. PMCID:PMC2048538. **Cited 249 times**.
b. Zhang JX, **Ma PX**. Cyclodextrin-based supramolecular systems for drug delivery: Recent progress and future perspective. ***Advanced Drug Delivery Reviews*** **2013**, 65:1215-1233. PMCID: PMC3885994. **Cited 386 times.**
c. hang X, Li Y, Chen YE, Chen J and **Ma PX**. Cell-free 3D scaffold with two-stage delivery of miRNA-26a to regenerate critical sized bone defects. ***Nature Communications 2016,*** 7: Article 10376. PMCID: PMC4735608. **Cited 49 times.**
d. M Dang, AJ Koh, X Jin, LK McCauley and **PX Ma**. Local pulsatile PTH delivery regenerates bone defect via enhanced bone remodeling in a cell-free scaffold. ***Biomaterials 2017***, 114:1-9. PMCID: PMC5125900. *Editors’ Choice:* ***Science Translational Medicine*** 23 Nov 2016: Vol. 8, Issue 366, pp. 366ec189 DOI: 10.1126/scitranslmed.aal2797. **Cited 15 times.**

D. Additional Information: Research Support and/or Scholastic Performance

(PIs: Ma, PX & McCauley, LK) NIH R01 DE022327 7/01/17-3/31/23
Biomimetics for Craniofacial Regeneration
Specific Aims: To develop biomimetic biodegradable polymer microspheres to induce macrophage efferocytosis-mediated bone regeneration.

(PIs: Ma, PX & Chen, YE) NIH R01HL136231 12/21/2016-12/31/2020
Two-stage miRNA delivering scaffolds for patient-originated cells to regenerate blood vessels

Specific Aims: To examine the mechanisms of SMC differentiation and develop technologies to engineer 3D vascular tissue using patient-originated cells.

(PI: Ma, PX) NIH R42TR001711 6/1/2017-4/30/2020
A Nanoparticle Delivery System for CRISPR/Cas9 Based Therapeutics
Specific Aims: To develop polymeric nanoparticles for CRISPR/Cas9 based gene editing therapeutic application.

(PI: Ma, PX) NIH U24 DE026915-ITP Project 3/1/2018-2/28/2019
Pulsatile PTH Delivery for Local Bone Regeneration
Specific Aims: To evaluate the efficacy of pulsatile PTH delivery in local bone regeneration using a rabbit model.

(PI: Levi, B; Co-I: Ma, PX) NIH R01 AR071379 4/1/2017-3/31/2022
Targeting molecular and cellular mediators of inflammation to prevent pathologic cell differentiation and heterotopic ossification
Specific Aims: To show that intracellular *Hif-1*α regulates SDF-1 production by mesenchymal cells in response to injury, macrophages contribute to ectopic chondrogenesis following injury through BMP2 production, and to develop a novel drug delivery strategy to target macrophages.

(PI: Levi, B; Co-I: Ma, PX) NIH R01 GM123069 7/1/2017-6/30/2022
Developing new diagnostic and timed, TAK1 specific treatment strategies for trauma induced heterotopic ossification
Specific Aims: To test the hypothesis that TAK1 is critical in chondrogenesis and osteogenesis and knocking down TAK1 at proper time can mitigate heterotopic ossification.

(PI: Yang, B; Co-I: Ma, PX) NIH 1R01HL141891 04/01/18-03/31/23
Define the mechanisms of aortopathy in bicuspid aortic valve patients
The proposed studies will produce new insights on aortopathy in BAV, define the cellular and molecular basis underlying the aortic aneurysm formation in BAV patients, and elucidate the biomechanical properties of diseased and control vessels.

(PIs: Kohn, D & Giannobile, W; Co-I: Ma, PX) NIH1U24DE026915 2/1/17-1/31/20
Michigan-Pittsburgh-Wyss Resource Center: Supporting Regenerative Medicine in Dental, Oral and Craniofacial Technologies
Specific Aims: Resource center to support regenerative medicine in dental, oral & craniofacial technologies.
Role: Co-Investigator

Recently Completed Projects (within last 3 years)

(Ma, PX & McCauley, LK) NIH R01 DE022327 4/01/2012-12/31/2017
PTH and Calcium Synergy for Craniofacial Regeneration
The purpose of this study is to test the hypothesis that a local delivery application of PTH can be orchestrated to drive osseous wound healing by co-opting biologic mediators of osteoclastic activity and calcium availability.

(Ma, PX & Chen, YE) NIH/NHLBI 1R01HL114038 1/07/2013-12/31/2017
Regenerating Blood Vessels Using iPS Cells
The main goals are to investigate the role of Yap1 in differentiation of iPS cells towards smooth muscle cells and to develop biomimetic scaffolds and biomolecule delivery system for blood vessel regeneration.

(Ma, PX) Amgen Inc 5/25/2012-12/31/2016
Biomolecule-releasing Scaffolds for Bone Regeneration
The major goal of this study is to develop biomolecule-releasing scaffolds for bone regeneration.

(Ma, PX) DOD W81XWH-12-2-0008 12/15/2011-1/14/2016
Biomimetic Delivery of Biomolecules for Craniofacial Bone Regeneration
To develop bone regenerative therapy using PTH, BMP, and biomimetic scaffolds.

(Ma, PX) NSF DMR-1206575 9/01/2012-8/31/2015
Novel Injectable Carriers for Regeneration
The major goal of the project is to synthesize star-shaped poly(L-lactic acid) with various branch numbers and lengths to self-assemble into nanofibrous hollow microspheres and impart biomolecule-releasing capacity to direct stem cell differentiation for regeneration.

Pending

(PIs: PX Ma (contact), Y Mishina and NE Hatch) NIH 1R01DE027662 9/01/18-8/31/23
Regenerating cranial suture (**Priority score: 20, Percentile: 3.0%**)
Specific Aims: To engineering cranial suture by designing biomimetic scaffolds to maintain suture mesenchymal stem cells and delivering mutant signaling inhibitors to rescue phenotype.

Overlap: None