

# Final Progress Report for Research Projects Funded by Health Research Grants

Instructions: Please complete all of the items as instructed. Do not delete instructions. Do not leave any items blank; responses must be provided for all items. If your response to an item is “None”, please specify “None” as your response. “Not applicable” is not an acceptable response for any of the items. There is no limit to the length of your response to any question. Responses should be single-spaced, no smaller than 12-point type. The report **must be completed using MS Word**. Submitted reports must be Word documents; they should not be converted to pdf format. Questions? Contact Health Research Program staff at 717-783-2548.

1. **Grantee Institution:** Pittsburgh Tissue Engineering Initiative
2. **Reporting Period (start and end date of grant award period):** 1/1/2012 – 12/31/2012
3. **Grant Contact Person (First Name, M.I., Last Name, Degrees):** Charlotte Emig
4. **Grant Contact Person’s Telephone Number:** 412-624-5518
5. **Grant SAP Number:** 4100057681
6. **Project Number and Title of Research Project:** Electrospun Scaffold Substrata for Culture of Osteoprogenitor Cells
7. **Start and End Date of Research Project:** 1/1/2012 – 12/31/12
8. **Name of Principal Investigator for the Research Project:** Richard Koepsel, PhD
9. **Research Project Expenses.** \$7,495

9(A) Please provide the total amount of health research grant funds spent on this project for the entire duration of the grant, including indirect costs and any interest earned that was spent:

\$ 7,495

9(B) Provide the last names (include first initial if multiple individuals with the same last name are listed) of **all** persons who worked on this research project and were supported with health research funds. Include position titles (Principal Investigator, Graduate Assistant, Post-doctoral Fellow, etc.), percent of effort on project and total health research funds expended for the position. For multiple year projects, if percent of effort varied from year to year, report in the % of Effort column the effort by year 1, 2, 3, etc. of the project (x% Yr 1; z% Yr 2-3).

Last Name	Position Title	% of Effort on Project	Cost
Koepsel	Principle Investigator	8%	\$7,050

9(C) Provide the names of **all** persons who worked on this research project, but who *were not* supported with health research funds. Include position titles (Research Assistant, Administrative Assistant, etc.) and percent of effort on project. For multiple year projects, if percent of effort varied from year to year, report in the % of Effort column the effort by year 1, 2, 3, etc. of the project (x% Yr 1; z% Yr 2-3).

Last Name	Position Title	% of Effort on Project
D'Souza	Post-Doctoral Fellow	5%
Andersen	Technician	5%

9(D) Provide a list of **all** scientific equipment purchased as part of this research grant, a short description of the value (benefit) derived by the institution from this equipment, and the cost of the equipment.

Type of Scientific Equipment	Value Derived	Cost
None		

**10. Co-funding of Research Project during Health Research Grant Award Period.** Did this research project receive funding from any other source during the project period when it was supported by the health research grant?

Yes \_\_\_\_\_ No X \_\_\_\_\_

If yes, please indicate the source and amount of other funds:

### 11. Leveraging of Additional Funds

11(A) As a result of the health research funds provided for this research project, were you able to apply for and/or obtain funding from other sources to continue or expand the research?

Yes X \_\_\_\_\_ No \_\_\_\_\_

If yes, please list the applications submitted (column A), the funding agency (National Institutes of Health—NIH, or other source in column B), the month and year when the application was submitted (column C), and the amount of funds requested (column D). If you have received a notice that the grant will be funded, please indicate the amount of funds to be awarded (column E). If the grant was not funded, insert “not funded” in column E.

Do not include funding from your own institution or from CURE (tobacco settlement funds). Do not include grants submitted prior to the start date of the grant as shown in Question 2. If

you list grants submitted within 1-6 months of the start date of this grant, add a statement below the table indicating how the data/results from this project were used to secure that grant.

A. Title of research project on grant application	B. Funding agency (check those that apply)	C. Month and Year Submitted	D. Amount of funds requested:	E. Amount of funds to be awarded:
Polymer Modification of Cell Surfaces for Tissue Specific Partitioning	X NIH <input type="checkbox"/> Other federal (specify:_____) <input type="checkbox"/> Nonfederal source (specify:_)	10/2012	\$415,137	\$

11(B) Are you planning to apply for additional funding in the future to continue or expand the research?

Yes \_\_\_\_\_ No  X

If yes, please describe your plans:

**12. Future of Research Project.** What are the future plans for this research project?

This project has ended

**13. New Investigator Training and Development.** Did students participate in project supported internships or graduate or post-graduate training for at least one semester or one summer?

Yes \_\_\_\_\_ No  x

If yes, how many students? Please specify in the tables below:

	Undergraduate	Masters	Pre-doc	Post-doc
Male				
Female				
Unknown				
<b>Total</b>				

	Undergraduate	Masters	Pre-doc	Post-doc
Hispanic				
Non-Hispanic				
Unknown				
<b>Total</b>				

	Undergraduate	Masters	Pre-doc	Post-doc
White				
Black				
Asian				
Other				
Unknown				
<b>Total</b>				

**14. Recruitment of Out-of-State Researchers.** Did you bring researchers into Pennsylvania to carry out this research project?

Yes \_\_\_\_\_ No x \_\_\_\_\_

If yes, please list the name and degree of each researcher and his/her previous affiliation:

**15. Impact on Research Capacity and Quality.** Did the health research project enhance the quality and/or capacity of research at your institution?

Yes \_\_\_\_\_ No x \_\_\_\_\_

If yes, describe how improvements in infrastructure, the addition of new investigators, and other resources have led to more and better research.

**16. Collaboration, business and community involvement.**

16(A) Did the health research funds lead to collaboration with research partners outside of your institution (e.g., entire university, entire hospital system)?

Yes \_\_\_\_\_ No x \_\_\_\_\_

If yes, please describe the collaborations:

16(B) Did the research project result in commercial development of any research products?

Yes \_\_\_\_\_ No x \_\_\_\_\_

If yes, please describe commercial development activities that resulted from the research project:

16(C) Did the research lead to new involvement with the community?

Yes \_\_\_\_\_ No x \_\_\_\_\_

If yes, please describe involvement with community groups that resulted from the research project:

**17. Progress in Achieving Research Goals, Objectives and Aims.**

List the project goals, objectives and specific aims (as contained in the grant agreement). Summarize the progress made in achieving these goals, objectives and aims for the period that the project was funded (i.e., from project start date through end date). Indicate whether or not each goal/objective/aim was achieved; if something was not achieved, note the reasons why. Describe the methods used. If changes were made to the research goals/objectives/aims, methods, design or timeline since the original grant application was submitted, please describe the changes. Provide detailed results of the project. Include evidence of the data that was generated and analyzed, and provide tables, graphs, and figures of the data. List published abstracts, poster presentations and scientific meeting presentations at the end of the summary of progress; peer-reviewed publications should be listed under item 20.

This response should be a DETAILED report of the methods and findings. It is not sufficient to state that the work was completed. Insufficient information may result in an unfavorable performance review, which may jeopardize future funding. If research findings are pending publication you must still include enough detail for the expert peer reviewers to evaluate the progress during the course of the project.

Health research grants funded under the Tobacco Settlement Act will be evaluated via a performance review by an expert panel of researchers and clinicians who will assess project work using this Final Progress Report, all project Annual Reports and the project's strategic plan. After the final performance review of each project is complete, approximately 12-16 months after the end of the grant, this Final Progress Report, as well as the Final Performance Review Report containing the comments of the expert review panel, and the grantee's written response to the Final Performance Review Report, will be posted on the CURE Web site.

**There is no limit to the length of your response. Responses must be single-spaced below, no smaller than 12-point type. If you cut and paste text from a publication, be sure symbols print properly, e.g., the Greek symbol for alpha ( $\alpha$ ) and beta ( $\beta$ ) should not print as boxes (□) and include the appropriate citation(s). DO NOT DELETE THESE INSTRUCTIONS.**

The goal of this research was to produce a substratum to test the binding and differentiation of polymer modified cells. The substratum was to be a bed of electrospun collagen fibers with inclusions of nanoparticulate hydroxyapatite as a synthetic mimic for bone tissue. The research goals could be by producing a stable substrate along with properly modified cells that could bind to and grow on the substratum.

### Electrospun collagen/hydroxyapatite fibers.

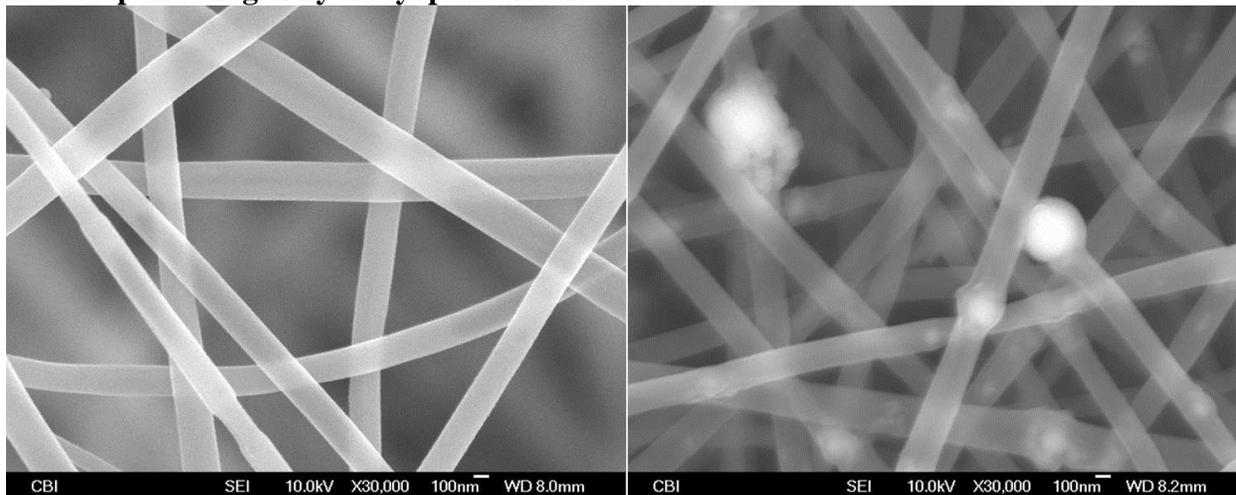


Figure 1

Collagen -4%

Collagen (4%) + HA (15%)

Electro-spun collagen hydroxyapatite composite fiber mats

The best results, as shown in Figure 1, produced collagen fibers with HA inclusions that were representative of bone structure. Unfortunately these structures were not stable in the media required for cell growth. Attempts were made to blend the collagen with other polymers (in particular polyacrylonitrile). These combinations failed to make materials with sufficient structural integrity to act as cell scaffolds. During our attempt to make a polymer blend with the proper characteristics we became aware of an article published which substantially described the work we were doing. The article, Wei Song, David C Markel, Sunxi Wang, Tong Shi, Guangzhao Mao, and Weiping Ren. Electrospun polyvinyl alcohol–collagen–hydroxyapatite nanofibers: a biomimetic extracellular matrix for osteoblastic cells. *Nanotechnology* 23 (2012) 115101 (15pp) [doi:10.1088/0957-4484/23/11/115101](https://doi.org/10.1088/0957-4484/23/11/115101), describes a polymer blend of collagen and polyvinyl alcohol that supports osteoblast growth. Because of this we concentrated the majority of our efforts on the production and analysis of the polymer coated cells.

## Polymer

The polymers used were synthesized in the lab and using atom transfer radical polymerization (ATRP). A schematic of the polymer is shown in Figure 2.

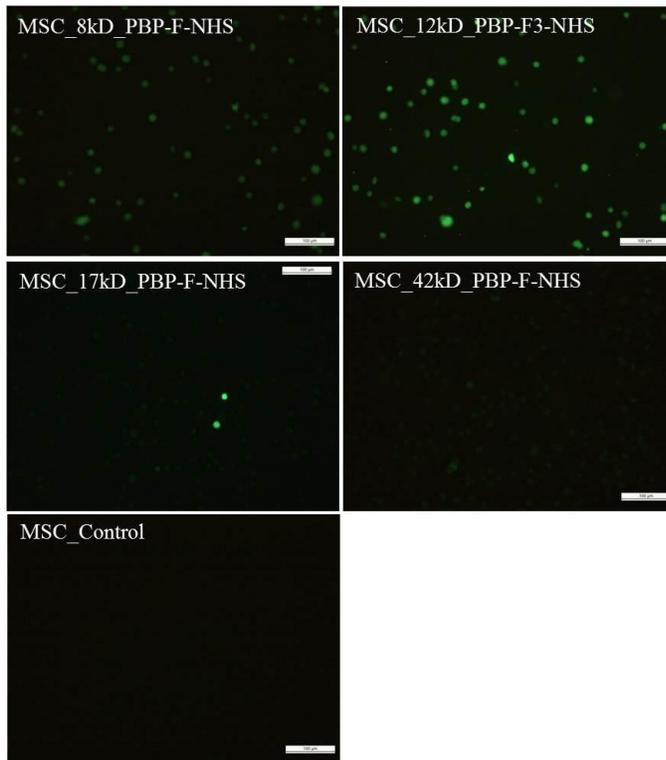
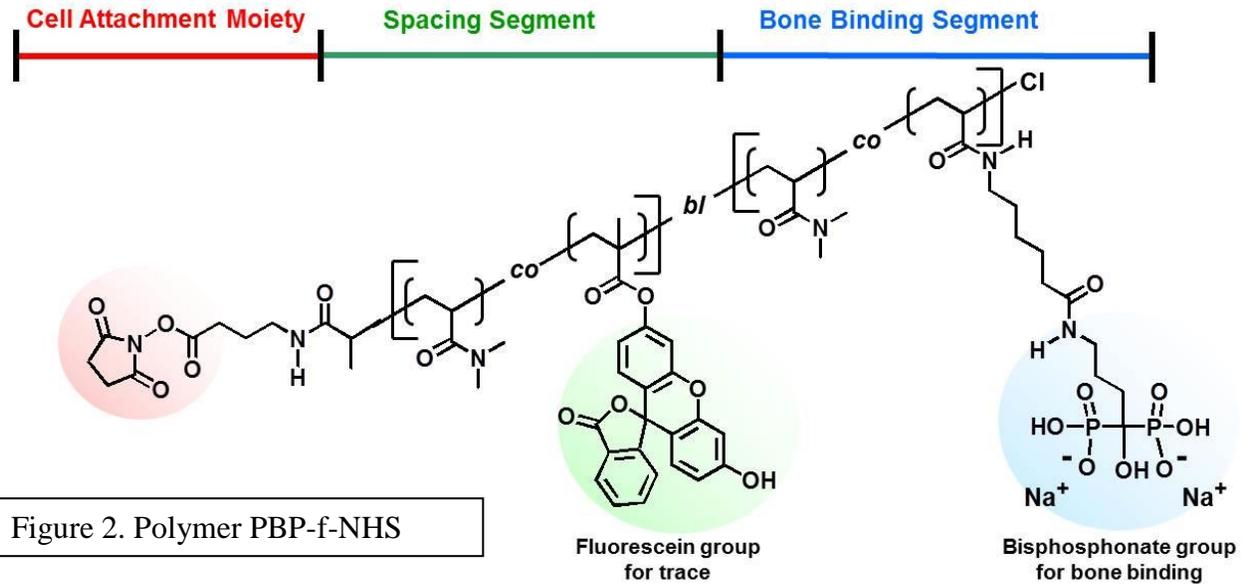


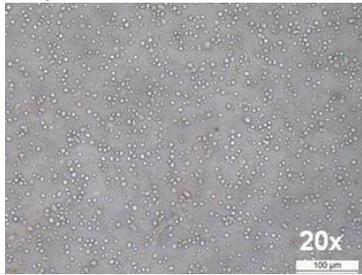
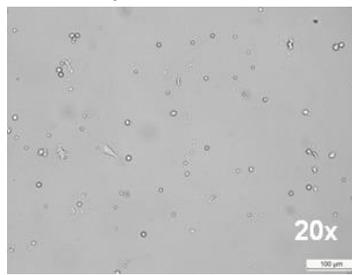
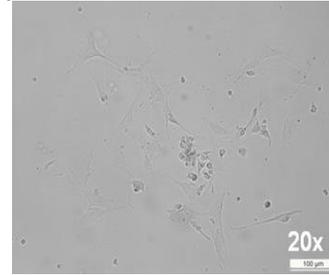
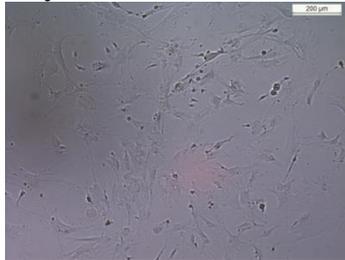
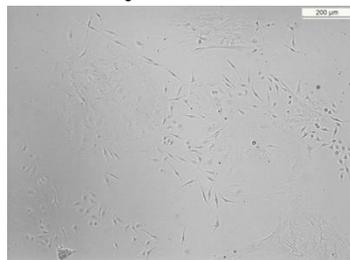
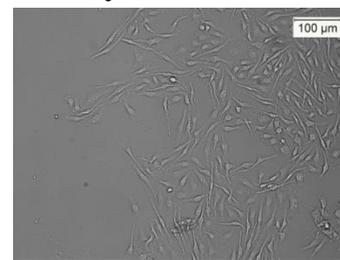
Figure 3. Fluorescence micrographs of polymer bound cells.

This polymer was made into a family of molecules with different molecular weights and tested for cell binding in Figure 3 below. The sizes of the polymer are designated as their molecular weights in kilo Daltons. Cell binding was seen with all of the tested polymers.

### Mouse MSC isolation.

MSCs were isolated from 8 week old C57-GFP mice.

Femoral and tibial bones were harvested from the mice and stored on ice in HBSS media with 1% Pen/Strep. Further manipulations were performed in laminar hood under sterile conditions. Epiphyses were cut using a rongeur, the bone marrow cavity was flushed with complete DMEM media (1% Ab/Am, 1% Glutamax, 10% FBS). The obtained solution was filtered using mesh filter, centrifuged at 300g for 5min and plated in 25 cm<sup>2</sup> culture flask. Media was changed 12 hours after. Further media was changed every 2-3 days.

**Day 0****Day 1****Day 2****Day 7****Day 18****Day 21**

The MSCs with polymer bound were tested for their ability to differentiate as described below. MSCs (1E6 cells per ml) were washed (centrifuged at 120g for 5 min) with 3ml PBS pH7.4, then 3ml of PBS at pH8.0, resuspended with 1ml PBS pH8.0. 1mg of PBP-f-NHS polymer (8KD) was dissolved with 10 $\mu$ l of DMSO. The cells were then added to the polymer, incubated in 37C water bath for 10min, spun in centrifuge at 120g for 5min, supernatant removed and washed with PBS pH7.4 3 times.

The control batch of cells were treated the same way without the polymer (wash with PBS pH7.4, then pH8.0, incubate in 37°C water bath and wash 3 times with PBS pH7.4)

Both tubes were resuspended in DMEM media and plated in 48-well culture plates.

For osteogenic differentiation cells were plated 7.5E3 cells per cm<sup>2</sup>.

For adipogenic differentiation cells were plated 2E4 cells per cm<sup>2</sup>.

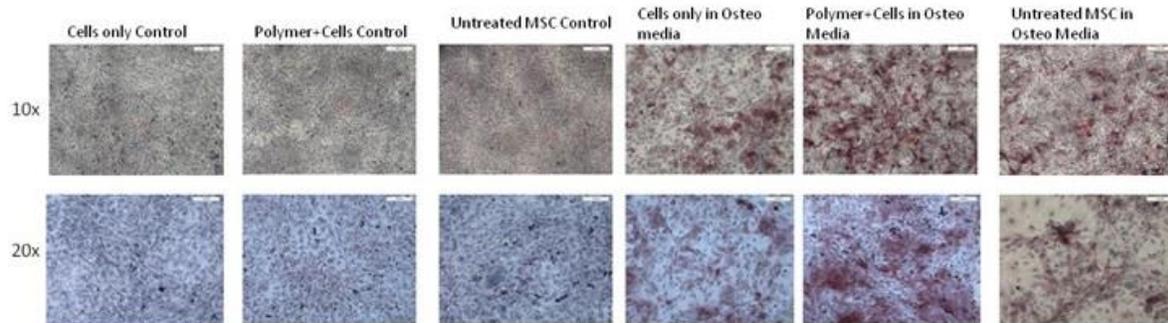
After 8 hours (when MSC were adherent to the plate), DMEM media was changed with osteogenic media (StemPro Osteogenesis differentiation media, Invitrogen) and adipogenic media (StemPro Adipogenesis differentiation media, Invitrogen) respectively. Control wells of polymer modified cells and no-polymer modified cells were left with DMEM media for each plate. Media then was changed every 1-2 days. Cells were cultured for 10 days.

At day 10, for osteogenesis alkaline phosphatase staining was performed.

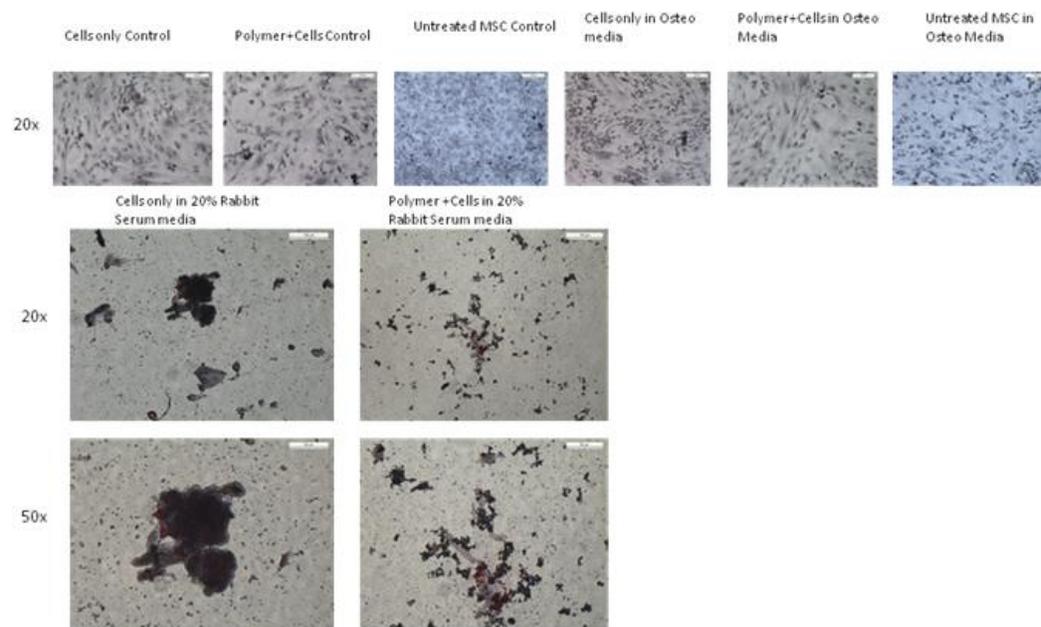
For adipogenesis Oil Red O staining was performed. The images were taken using Leica Microscope.

## Results:

### Osteogenic differentiation



### Adipogenic Differentiation



### Findings:

1. To determine osteogenic differentiation Alkaline Phosphatase was used as a marker. According to obtained images cells differentiated into osteoblasts in osteogenic media, and the control did not. There is no distinctive difference between differentiated MSCs and MSCs coated with polymer. Therefore it was assumed that polymer has no noticeable effect upon MSCs differentiation into osteoblasts.
2. Oil red O stain was used for adipogenic differentiation. Oil droplets forming inside the cells should have stained bright red. There were oil droplets in cells with StemPro Adipogenic Media. In wells with 20% Rabbit Serum Media there were several cells that had red oil droplets

inside. The results indicate differentiation of the MSC but were insufficient for statistical analysis to assess the influence of the polymer upon adipogenic differentiation of MSCs.

### Conclusions

The cells tolerate the polymer quite well and should provide added bone binding capability. The next step for this research is to test our polymer bound cells with the PVA-collagen-HA electrospun polymer scaffolds previously described (Wei Song, David C Markel, Sunxi Wang, Tong Shi, Guangzhao Mao, and Weiping Ren. Electrospun polyvinyl alcohol–collagen–hydroxyapatite nanofibers: a biomimetic extracellular matrix for osteoblastic cells. *Nanotechnology* 23 (2012) 115101 (15pp) [doi:10.1088/0957-4484/23/11/115101](https://doi.org/10.1088/0957-4484/23/11/115101)).

**18. Extent of Clinical Activities Initiated and Completed.** Items 18(A) and 18(B) should be completed for all research projects. If the project was restricted to secondary analysis of clinical data or data analysis of clinical research, then responses to 18(A) and 18(B) should be “No.”

18(A) Did you initiate a study that involved the testing of treatment, prevention or diagnostic procedures on human subjects?

Yes  
 No

18(B) Did you complete a study that involved the testing of treatment, prevention or diagnostic procedures on human subjects?

Yes  
 No

**If “Yes” to either 18(A) or 18(B), items 18(C) – (F) must also be completed.** (Do NOT complete 18(C-F) if 18(A) and 18(B) are both “No.”)

18(C) How many hospital and health care professionals were involved in the research project?

\_\_\_\_\_ Number of hospital and health care professionals involved in the research project

18(D) How many subjects were included in the study compared to targeted goals?

\_\_\_\_\_ Number of subjects originally targeted to be included in the study  
\_\_\_\_\_ Number of subjects enrolled in the study

**Note:** Studies that fall dramatically short on recruitment are encouraged to provide the details of their recruitment efforts in Item 17, Progress in Achieving Research Goals, Objectives and Aims. For example, the number of eligible subjects approached, the number that refused to participate and the reasons for refusal. Without this information it is difficult to discern whether eligibility criteria were too restrictive or the study simply did not appeal to subjects.

18(E) How many subjects were enrolled in the study by gender, ethnicity and race?

Gender:

Males  
 Females  
 Unknown

Ethnicity:

Latinos or Hispanics  
 Not Latinos or Hispanics  
 Unknown

Race:

American Indian or Alaska Native  
 Asian  
 Blacks or African American  
 Native Hawaiian or Other Pacific Islander  
 White  
 Other, specify: \_\_\_\_\_  
 Unknown

18(F) Where was the research study conducted? (List the county where the research study was conducted. If the treatment, prevention and diagnostic tests were offered in more than one county, list all of the counties where the research study was conducted.)

**19. Human Embryonic Stem Cell Research.** Item 19(A) should be completed for all research projects. If the research project involved human embryonic stem cells, items 19(B) and 19(C) must also be completed.

19(A) Did this project involve, in any capacity, human embryonic stem cells?

Yes  
 No

19(B) Were these stem cell lines NIH-approved lines that were derived outside of Pennsylvania?

Yes  
 No

19(C) Please describe how this project involved human embryonic stem cells:

**20. Articles Submitted to Peer-Reviewed Publications.**

20(A) Identify all publications that resulted from the research performed during the funding

period and that have been submitted to peer-reviewed publications. Do not list journal abstracts or presentations at professional meetings; abstract and meeting presentations should be listed at the end of item 17. **Include only those publications that acknowledge the Pennsylvania Department of Health as a funding source** (as required in the grant agreement). List the title of the journal article, the authors, the name of the peer-reviewed publication, the month and year when it was submitted, and the status of publication (submitted for publication, accepted for publication or published.). Submit an electronic copy of each publication or paper submitted for publication, listed in the table, in a PDF version 5.0.5 (or greater) format, 1,200 dpi. Filenames for each publication should include the number of the research project, the last name of the PI, the number of the publication and an abbreviated research project title. For example, if you submit two publications for PI Smith for the “Cognition and MRI in Older Adults” research project (Project 1), and two publications for PI Zhang for the “Lung Cancer” research project (Project 3), the filenames should be:

- Project 1 – Smith – Publication 1 – Cognition and MRI
- Project 1 – Smith – Publication 2 – Cognition and MRI
- Project 3 – Zhang – Publication 1 – Lung Cancer
- Project 3 – Zhang – Publication 2 – Lung Cancer

If the publication is not available electronically, provide 5 paper copies of the publication.

**Note:** The grant agreement requires that recipients acknowledge the Pennsylvania Department of Health funding in all publications. Please ensure that all publications listed acknowledge the Department of Health funding. If a publication does not acknowledge the funding from the Commonwealth, do not list the publication.

Title of Journal Article:	Authors:	Name of Peer-reviewed Publication:	Month and Year Submitted:	Publication Status (check appropriate box below):
1. None				<input type="checkbox"/> Submitted <input type="checkbox"/> Accepted <input type="checkbox"/> Published

20(B) Based on this project, are you planning to submit articles to peer-reviewed publications in the future?

Yes \_\_\_\_\_ No   x  

If yes, please describe your plans:

**21. Changes in Outcome, Impact and Effectiveness Attributable to the Research Project.**

Describe the outcome, impact, and effectiveness of the research project by summarizing its impact on the incidence of disease, death from disease, stage of disease at time of diagnosis, or other relevant measures of outcome, impact or effectiveness of the research project. If there were no changes, insert “None”; do not use “Not applicable.” Responses must be

single-spaced below, and no smaller than 12-point type. DO NOT DELETE THESE INSTRUCTIONS. There is no limit to the length of your response.

None

**22. Major Discoveries, New Drugs, and New Approaches for Prevention Diagnosis and Treatment.** Describe major discoveries, new drugs, and new approaches for prevention, diagnosis and treatment that are attributable to the completed research project. If there were no major discoveries, drugs or approaches, insert “None”; do not use “Not applicable.” Responses must be single-spaced below, and no smaller than 12-point type. DO NOT DELETE THESE INSTRUCTIONS. There is no limit to the length of your response.

None

**23. Inventions, Patents and Commercial Development Opportunities.**

23(A) Were any inventions, which may be patentable or otherwise protectable under Title 35 of the United States Code, conceived or first actually reduced to practice in the performance of work under this health research grant? Yes \_\_\_\_\_ No   x  

If “Yes” to 23(A), complete items a – g below for each invention. (Do NOT complete items a - g if 23(A) is “No.”)

- a. Title of Invention:
- b. Name of Inventor(s):
- c. Technical Description of Invention (describe nature, purpose, operation and physical, chemical, biological or electrical characteristics of the invention):
- d. Was a patent filed for the invention conceived or first actually reduced to practice in the performance of work under this health research grant?  
Yes \_\_\_\_\_ No

If yes, indicate date patent was filed:

- e. Was a patent issued for the invention conceived or first actually reduced to practice in the performance of work under this health research grant?  
Yes \_\_\_\_\_ No

If yes, indicate number of patent, title and date issued:

Patent number:

Title of patent:

Date issued:

- f. Were any licenses granted for the patent obtained as a result of work performed under this health research grant? Yes\_\_\_\_\_ No\_\_\_

If yes, how many licenses were granted?\_\_\_\_\_

- g. Were any commercial development activities taken to develop the invention into a commercial product or service for manufacture or sale? Yes\_\_\_ No\_\_\_

If yes, describe the commercial development activities:

23(B) Based on the results of this project, are you planning to file for any licenses or patents, or undertake any commercial development opportunities in the future?

Yes\_\_\_\_\_ No\_\_\_x\_\_\_\_\_

If yes, please describe your plans:

**24. Key Investigator Qualifications.** Briefly describe the education, research interests and experience and professional commitments of the Principal Investigator and all other key investigators. In place of narrative you may insert the NIH biosketch form here; however, please limit each biosketch to 1-2 pages. *For Nonformula grants only – include information for only those key investigators whose biosketches were not included in the original grant application.*

## BIOGRAPHICAL SKETCH

NAME <b>Richard R. Koepsel, Ph.D.</b>	POSITION TITLE <b>Research Professor</b>		
eRA COMMONS USER NAME <b>koepsel</b>			
EDUCATION/TRAINING <i>(Begin with baccalaureate or other initial professional education, such as nursing, and include postdoctoral training.)</i>			
INSTITUTION AND LOCATION	DEGREE <i>(if applicable)</i>	YEAR(s)	FIELD OF STUDY
<b>University of Wisconsin, Madison WI</b>	<b>BS</b>	<b>1974</b>	<b>Bacteriology</b>
<b>University of Wisconsin, Madison WI</b>	<b>MS</b>	<b>1977</b>	<b>Pharmacognosy</b>
<b>University of Wisconsin, Madison WI</b>	<b>Ph.D.</b>	<b>1981</b>	<b>Bacteriology</b>
<b>University of Pittsburgh, Pittsburgh PA</b>	<b>Post-doc</b>	<b>1982-1987</b>	<b>Molecular Biology</b>

### A. Personal Statement

I have over 30 years of experience in research projects involving bacteria and antimicrobials. Over the past 10 years I have worked with Dr Alan Russell studying antimicrobial surfaces and polymeric antimicrobial materials. We have been able to synthesize antimicrobial polyquaternary amines and to characterize their mechanism of action. Additionally we have recently synthesized a new class of antimicrobial materials which generate active halogens using immobilized enzymes acting on glucose and halide salts.

### B. Professional Experience

February 1987 – June 1999	Assistant Professor Department of Microbiology-Biochemistry School of Dental Medicine University of Pittsburgh
July 1999 – July 2009	Research Associate Professor University of Pittsburgh Department of Chemical and Petroleum Engineering Center for Biotechnology and Bioengineering 300 Technology Drive Pittsburgh PA 15219
July 2009 – present	Research Professor University of Pittsburgh Department of Surgery McGowan Institute for Regenerative Medicine 450 Technology Drive Pittsburgh PA 15219

### C. Selected Publications

- Amitai G, Murata H, Andersen J, **Koepsel R**, Russell AJ. Decontamination of chemical and biological warfare agents with a single multifunctional material. *Biomaterials*. 31:4417–4425. 2010.
- Amitai G, Andersen J, Wargo S, Asche G, Chir J, **Koepsel R**, Russell AJ. Polyurethane-based leukocyte-inspired biocidal materials. *Biomaterials*. 30:6522-6529. 2009.
- Liu Z., Bartlow P., Dilmore R.M., Soong Y., Pan Z., **Koepsel R.**, Atai M. Production, purification, and characterization of a fusion protein of carbonic anhydrase from *Neisseria gonorrhoeae* and cellulose binding domain from *Clostridium thermocellum*. *Biotech Progress*. 2009. 25:68-74.
- Huang J, **Koepsel RR**, Murata H, Wu W, Lee SB, Kowalewski T, Russell AJ, and Matyjaszewski K. Nonleaching Antibacterial Glass Surfaces via "Grafting Onto": The Effect of the Number of Quaternary Ammonium Groups on Biocidal Activity. *Langmuir* 2008 24:6785-6795.
- Cunningham D, Liu Z, Domagalski N, **Koepsel RR**, Atai MM, and Domach MM. Pyruvate Kinase-Deficient *Escherichia coli* Exhibits Increased Plasmid Copy Number and Cyclic AMP Levels *J. Bacteriol.* 2009. 191: 3041–3049.
- Murata H, **Koepsel RR**, Matyjaszewski K and Russell AJ,. Permanent, non-leaching antibacterial surfaces How high density cationic surfaces kill bacterial cells *Biomaterials* 2007, 28: 4870-4879.
- Huang J, Murata H, **Koepsel RR**, Russell AJ, and Matyjaszewski K. Antibacterial Polypropylene via Surface-Initiated Atom Transfer Radical Polymerization. *Biomacromolecules* 8:1396-1399, 2007.
- Ravikumar T, Murata H, **Koepsel RR**, and AJ Russell. Surface-Active Antifungal Polyquaternary Amine. *Biomacromolecules* 7: 2762-2769, 2006
- Lee SB, **Koepsel RR**, Russell AJ Surface dispersion and hardening of self-assembled diacetylene nanotubes *NANO LETTERS* 5: 2202-2206, 2005
- Zhu T, Pan Z, Domagalski N, **Koepsel R**, Atai MM, Domach MM. Engineering of *Bacillus subtilis* for enhanced total synthesis of folic acid. *APPLIED AND ENVIRONMENTAL MICROBIOLOGY* 71: 7122-7129, 2005
- Lee SB, **Koepsel RR**, Morley SW, Matyjaszewski K, Sun YJ, Russell AJ. Permanent, nonleaching antibacterial surfaces. 1. Synthesis by atom transfer radical polymerization *BIOMACROMOLECULES* 5:877-882 2004
- Lee SB, **Koepsel R**, Stolz DB, Warriner HE, Russell AJ. Self-assembly of biocidal nanotubes from a single-chain diacetylene amine salt *JOURNAL OF THE AMERICAN CHEMICAL SOCIETY* 126: 13400-13405 2004
- Russell, AJ, Drevon GF, Berberich, JA, and **Koepsel RR**. Biomaterials for mediation of chemical and biological warfare agents. *Annual Review of Biomedical Engineering*. 5:1-27, 2003
- Koepsel RR**, Russell AJ. Directed capture of enzymes and bacteria on bioplastic films. *Biomacromolecules* 4: 850-82755 2003
- Fry B., Zhu T., Domach M.M., **Koepsel R.R.**, Phalakornkule C., and Atai M.M. Characterization of growth and acid formation in a pyruvate kinase mutant of *Bacillus subtilis*. *Appl. Environ. Microbiol.* 66:4045-4049. 2000