e. 7			
MASTER COPY	KEEP THIS CC		
REPORT DO	CUMENTATION	AD-A25	5 658
Public reporting burgen for this collection of inform gathering and maintaining the data needed, and co	nation is estimated to average 1 hol mpleting and reviewing the collection		E EN THE NEW CONTRACTOR SOURCE
collection of information, including suggestions for Davis Highway, Suite 1204, Arlington, VA 22202-430	b2, and to the Office of Managemer		20503.
1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	S. ALTUNI LITE AND	
	14 August 1992	Final Report -	6/15/89 - 6/14/92
A. TITLE AND SUBTILLE			S. FUNDING NUMBERS
Molecular Biology of Ana	erobic Aromatic Bio	odegradation	DAAL03-89-K-0121
5 AUTHOR(S)			
Caroline S. Harwood			
7. PERFORMING ORGANIZATION NAM	E(S) AND ADD ESS(ES)	-1092 - 10	B. PERFORMING ORGANIZATION
Department of Microbi	ology		~ ~~~~
University of Iowa			2-255/5
Iowa City, IA 5224	2		LUMA ANN ANN ANN ANN AN AN
. SPONSORING/MONITORING AGENC	Y NAME(S) AND ADDRESS(ES	V	940.
U. S. Army Research Off	ire		AGENCY REPORT NUMBER
P. O. Box 12211	1.6		
Research Triangle Park.	NC 27709-2211		
0 ,			
14 CURRE FARENTARY MOTES			
11. SUPPLEMENTARY NOTES	or findings contain	ed in this report	are those of the
11. SUPPLEMENTARY NOTES The view, opinions and/ author(s) and should no	or findings contain t be construed as a	ed in this report n official Departm	are those of the ment of the Army
11. SUPPLEMENTARY NOTES The view, opinions and/ author(s) and should no position, policy, or de	or findings contain t be construed as a cision, unless so_d	ed in this report n official Departm esignated by other	are those of the ment of the Army r documentation.
11. SUPPLEMENTARY NOTES The view, opinions and/ author(s) and should no position, policy, or de 12a. DISTRIBUTION/AVAILABILITY STA	or findings contain t be construed as a cision, unless so d ATEMENT	ed in this report n official Departm esignated by other 1	are those of the ment of the Army r documentation. 2b. DISTRIBUTION CODE
11. SUPPLEMENTARY NOTES The view, opinions and/ author(s) and should no position, policy, or de 12a. DISTRIBUTION/AVAILABILITY STA	or findings contain t be construed as a cision, unless so d ATEMENT	ed in this report n official Departm esignated by other 1	are those of the ment of the Army r documentation. 2b. DISTRIBUTION CODE
11. SUPPLEMENTARY NOTES The view, opinions and/ author(s) and should no position, policy, or de 12a. DISTRIBUTION/AVAILABILITY STA Approved for public re	or findings contain t be construed as a cision, unless so_d NTEMENT elease; distribution	ed in this report n official Departm esignated by other n unlimited.	are those of the ment of the Army r documentation. 2b. DISTRIBUTION CODE
11. SUPPLEMENTARY NOTES The view, opinions and/ author(s) and should no position, policy, or de 12a. DISTRIBUTION/AVAILABILITY STA Approved for public re	or findings contain of be construed as a <u>scision, unless so d</u> ATEMENT elease; distribution	ed in this report n official Departm esignated by other n unlimited.	are those of the ment of the Army r documentation. 2b. DISTRIBUTION CODE
11. SUPPLEMENTARY NOTES The view, opinions and/ author(s) and should no position, policy, or de 12a. DISTRIBUTION/AVAILABILITY STA Approved for public re	or findings contain t be construed as a cision, unless so d NTEMENT elease; distribution	ed in this report n official Departm esignated by other 1 n unlimited.	are those of the ment of the Army <u>r documentation.</u> 2b. DISTRIBUTION CODE
11. SUPPLEMENTARY NOTES The view, opinions and/ author(s) and should no position, policy, or de 12a. DISTRIBUTION / AVAILABILITY STA Approved for public re	or findings contain t be construed as a ccision, unless so d TEMENT elease; distribution	ed in this report n official Departm esignated by other n unlimited.	are those of the ment of the Army <u>r documentation.</u> 22b. DISTRIBUTION CODE
 SUPPLEMENTARY NOTES The view, opinions and/author(s) and should no position, policy, or de IZA. DISTRIBUTION/AVAILABILITY STA Approved for public restance ABSTRACT (Maximum 200 words) 	or findings contain of be construed as a <u>scision, unless so d</u> ATEMENT elease; distribution	ed in this report n official Departm esignated by other n unlimited.	are those of the ment of the Army <u>r documentation</u> . 2b. DISTRIBUTION CODE
11. SUPPLEMENTARY NOTES The view, opinions and/ author(s) and should no position, policy, or de 12a. DISTRIBUTION/AVAILABILITY STA Approved for public re 13. ABSTRACT (Maximum 200 words) Aromatic acids are i diverse aromatic compound	or findings contain t be construed as a cision, unless so d TEMENT elease; distribution ntermediates in the	ed in this report n official Department esignated by other n unlimited.	are those of the ment of the Army <u>r documentation.</u> 22b. DISTRIBUTION CODE
 II. SUPPLEMENTARY NOTES The view, opinions and/author(s) and should no position, policy, or de IZa. DISTRIBUTION / AVAILABILITY STA Approved for public res ABSTRACT (Maximum 200 words) Aromatic acids are i diverse aromatic compount by many metabolic types 	or findings contain t be construed as a cision, unless so d TEMENT elease; distribution ntermediates in the ds, including ligni of anaerobic bacter	ed in this report n official Department esignated by other n unlimited.	are those of the ment of the Army r documentation. 22b. DISTRIBUTION CODE f structurally vironmental pollutants, o the starting
11. SUPPLEMENTARY NOTES The view, opinions and/ author(s) and should no position, policy, or de 12a. DISTRIBUTION/AVAILABILITY STA Approved for public re 13. ABSTRACT (Maximum 200 words) Aromatic acids are i diverse aromatic compound by many metabolic types compounds for central pa	or findings contain t be construed as a cision, unless so d TEMENT elease; distribution ntermediates in the ds, including light of anaerobic bacter thways of anaerobic	e biodegradation of in monomers and en- ies is the second second second in monomers and en-	are those of the ment of the Army r documentation. 2b. DISTRIBUTION CODE f structurally vironmental pollutants, o the starting uction and fission.
11. SUPPLEMENTARY NOTES The view, opinions and/ author(s) and should no position, policy, or de 12a. DISTRIBUTION/AVAILABILITY STA Approved for public re 13. ABSTRACT (Maximum 200 words) Aromatic acids are i diverse aromatic compound by many metabolic types compounds for central pa We have identified and d	or findings contain t be construed as a cision, unless so d ATEMENT elease; distribution ds, including ligni of anaerobic bacter thways of anaerobic eveloped molecular	e biodegradation of in monomers and environmental designments and environments and envints and environments and environments and envi	are those of the ment of the Army r documentation. 22b. DISTRIBUTION CODE f structurally vironmental pollutants, o the starting uction and fission. used to manipulate
11. SUPPLEMENTARY NOTES The view, opinions and/ author(s) and should no position, policy, or de 12a. DISTRIBUTION/AVAILABILITY STA Approved for public re 13. ABSTRACT (Maximum 200 words) Aromatic acids are i diverse aromatic compound by many metabolic types compounds for central pa We have identified and d and clone genes for arom	or findings contain t be construed as a cision, unless so d TEMENT elease; distribution antermediates in the ds, including ligni of anaerobic bacter thways of anaerobic leveloped molecular atic acid degradati	e biodegradation of in monomers and en- ies is that can be confrom the bacter	are those of the ment of the Army r documentation. 22b. DISTRIBUTION CODE f structurally vironmental pollutants, o the starting uction and fission. used to manipulate rium, <u>Rhodopseudomonas</u>
11. SUPPLEMENTARY NOTES The view, opinions and/ author(s) and should no position, policy, or de 12a. DISTRIBUTION/AVAILABILITY STA Approved for public re 3. ABSTRACT (Maximum 200 words) Aromatic acids are i diverse aromatic compound by many metabolic types compounds for central pa We have identified and d and clone genes for arom palustris. These tools	or findings contain t be construed as a cision, unless so d TEMENT elease; distribution antermediates in the ds, including light of anaerobic bacter thways of anaerobic leveloped molecular matic acid degradati have enabled us to	e biodegradation of in monomers and en- is bindegradation of in monomers and en- ia. They are also benzene ring red tools that can be on from the bacter identify genes spo	are those of the ment of the Army r documentation. 20. DISTRIBUTION CODE f structurally vironmental pollutants, o the starting uction and fission. used to manipulate rium, <u>Rhodopseudomonas</u> ecifying two enzymes
11. SUPPLEMENTARY NOTES The view, opinions and/ author(s) and should no position, policy, or de 12a. DISTRIBUTION/AVAILABILITY STA Approved for public re 13. ABSTRACT (Maximum 200 words) Aromatic acids are i diverse aromatic compound by many metabolic types compounds for central pa We have identified and d and clone genes for arom palustris. These tools that initiate the degrad	or findings contain t be construed as a cision, unless so d TEMENT elease; distribution ds, including light of anaerobic bacter thways of anaerobic leveloped molecular have enabled us to ation of the compou	e biodegradation of in monomers and en- is benzene ring red tools that can be on from the bacter identify genes spond	are those of the ment of the Army r documentation. 2b. DISTRIBUTION CODE
11. SUPPLEMENTARY NOTES The view, opinions and/ author(s) and should no position, policy, or de 2a. DISTRIBUTION/AVAILABILITY STA Approved for public re 3. ABSTRACT (Maximum 200 words) Aromatic acids are i diverse aromatic compounds by many metabolic types compounds for central pa We have identified and d and clone genes for arom palustris. These tools that initiate the degrad and we have also cloned, for the automatic acide, for the autom	or findings contain t be construed as a cision, unless so d TEMENT elease; distribution of anaerobic bacter thways of anaerobic leveloped molecular atic acid degradati have enabled us to ation of the compou sequenced, and cha	e biodegradation of in monomers and en- is benzene ring redi- tools that can be on from the bacter identify genes spond racterized a regul	are those of the ment of the Army r documentation. The structurally vironmental pollutants, o the starting uction and fission. used to manipulate rium, <u>Rhodopseudomonas</u> ecifying two enzymes 4-hydroxybenzoate, latory gene required
11. SUPPLEMENTARY NOTES The view, opinions and/ author(s) and should no position, policy, or de la. DISTRIBUTION/AVAILABILITY STA Approved for public re 3. ABSTRACT (Maximum 200 words) Aromatic acids are i diverse aromatic compounds by many metabolic types compounds for central pa We have identified and d and clone genes for arom palustris. These tools that initiate the degrad and we have also cloned, for the expression of ar	or findings contain t be construed as a cision, unless so d TEMENT elease; distribution of anaerobic bacter thways of anaerobic eveloped molecular matic acid degradati have enabled us to ation of the compour sequenced, and cha omatic acid degrada anaerobic for	e biodegradation of in unlimited.	are those of the ment of the Army r documentation. The provide starting vironmental pollutants, o the starting uction and fission. used to manipulate rium, <u>Rhodopseudomonas</u> ecifying two enzymes 4-hydroxybenzoate, latory gene required us, the first steps sion in the absence
11. SUPPLEMENTARY NOTES The view, opinions and/ author(s) and should no position, policy, or de 12a. DISTRIBUTION/AVAILABILITY STA Approved for public re 13. ABSTRACT (Maximum 200 words) Aromatic acids are i diverse aromatic compound by many metabolic types compounds for central pa We have identified and d and clone genes for arom palustris. These tools that initiate the degrad and we have also cloned, for the expression of ar towards elucidating the of oxygen have been accounts	or findings contain t be construed as a <u>cision, unless so d</u> ATEMENT elease; distribution ds, including ligni of anaerobic bacter thways of anaerobic leveloped molecular have enabled us to latic acid degradati have enabled us to lation of the compou sequenced, and cha omatic acid degrada molecular basis for mplished.	e biodegradation of in monomers and en- cia. They are also be benzene ring red tools that can be on from the bacter identify genes spo inds benzoate and of tracterized a regulation benzene ring fiss	are those of the ment of the Army r documentation. The documentation. The documentation coose f structurally vironmental pollutants, o the starting uction and fission. used to manipulate rium, <u>Rhodopseudomonas</u> ecifying two enzymes 4-hydroxybenzoate, latory gene required us, the first steps sion in the absence
11. SUPPLEMENTARY NOTES The view, opinions and/ author(s) and should no position, policy, or de 12a. DISTRIBUTION/AVAILABILITY STA Approved for public re 13. ABSTRACT (Maximum 200 words) Aromatic acids are i diverse aromatic compound by many metabolic types compounds for central pa We have identified and d and clone genes for arom palustris. These tools that initiate the degrad and we have also cloned, for the expression of ar towards elucidating the of oxygen have been acco	or findings contain t be construed as a cision, unless so d ATEMENT elease; distribution ads, including light of anaerobic bacter thways of anaerobic eveloped molecular thave enabled us to atic acid degradati have enabled us to ation of the compou sequenced, and cha comatic acid degrada molecular basis for mplished.	e biodegradation of in unlimited.	are those of the ment of the Army r documentation. The documentation. The documentation code f structurally vironmental pollutants, o the starting uction and fission. used to manipulate rium, <u>Rhodopseudomonas</u> ecifying two enzymes 4-hydroxybenzoate, latory gene required us, the first steps sion in the absence
11. SUPPLEMENTARY NOTES The view, opinions and/ author(s) and should no position, policy, or de 12. DISTRIBUTION/AVAILABILITY STA Approved for public re 13. ABSTRACT (Maximum 200 words) Aromatic acids are i diverse aromatic compound by many metabolic types compounds for central pa We have identified and d and clone genes for arom palustris. These tools that initiate the degrad and we have also cloned, for the expression of ar towards elucidating the of oxygen have been acco 92. 9.22	or findings contain t be construed as a cision, unless so d ATEMENT elease; distribution antermediates in the dds, including light of anaerobic bacter thways of anaerobic leveloped molecular thatic acid degradati have enabled us to ation of the compou sequenced, and cha comatic acid degrada molecular basis for mplished. 0066	ed in this report n official Department esignated by other n unlimited.	are those of the ment of the Army r documentation. The documentation. The documentation code f structurally vironmental pollutants, o the starting uction and fission. used to manipulate rium, <u>Rhodopseudomonas</u> ecifying two enzymes 4-hydroxybenzoate, latory gene required us, the first steps sion in the absence
11. SUPPLEMENTARY NOTES The view, opinions and/ author(s) and should no position, policy, or de 12. DISTRIBUTION/AVAILABILITY STA Approved for public re 13. ABSTRACT (Maximum 200 words) Aromatic acids are i diverse aromatic compound by many metabolic types compounds for central pa We have identified and d and clone genes for arom palustris. These tools that initiate the degrad and we have also cloned, for the expression of ar towards elucidating the of oxygen have been acco 92 9 22 14. SUBJECT TERMS	or findings contain t be construed as a cision, unless so d ATEMENT elease; distribution antermediates in the ds, including light of anaerobic bacter thways of anaerobic eveloped molecular thave enabled us to lation of the compour sequenced, and cha omatic acid degradat molecular basis for mplished. 006	e biodegradation of ia. They are also be benzene ring reducted tools that can be on from the bacter identify genes spo inds benzoate and a racterized a regu tools ring fiss	are those of the ment of the Army r documentation. The second second second second second second second second second second sec
11. SUPPLEMENTARY NOTES The view, opinions and/ author(s) and should no position, policy, or de 12a. OISTRIBUTION/AVAILABILITY STA Approved for public re 13. ABSTRACT (Maximum 200 words) Aromatic acids are i diverse aromatic compound by many metabolic types compounds for central pa We have identified and d and clone genes for arom palustris. These tools that initiate the degrad and we have also cloned, for the expression of ar towards elucidating the of oxygen have been acco 92. 9.22 14. SUBJECT TERMS Biodegradation, Biotec	or findings contain t be construed as a cision, unless so d TEMENT elease; distribution antermediates in the dds, including light of anaerobic bacter thways of anaerobic leveloped molecular thave enabled us to latic acid degradati have enabled us to lation of the compou sequenced, and cha comatic acid degrada molecular basis for mplished. 006	e biodegradation of in unlimited.	are those of the ment of the Army r documentation. The observation code f structurally vironmental pollutants, o the starting uction and fission. used to manipulate rium, <u>Rhodopseudomonas</u> ecifying two enzymes 4-hydroxybenzoate, latory gene required us, the first steps sion in the absence 15. NUMBER OF PAGES 4
11. SUPPLEMENTARY NOTES The view, opinions and/ author(s) and should no position, policy, or de 12. OISTRIBUTION/AVAILABILITY STA Approved for public re 13. ABSTRACT (Maximum 200 words) Aromatic acids are i diverse aromatic compound by many metabolic types compounds for central pa We have identified and d and clone genes for arom palustris. These tools that initiate the degrad and we have also cloned, for the expression of ar towards elucidating the of oxygen have been acco 92.92.922 14. SUBJECT TERMS Biodegradation, Biotec	or findings contain t be construed as a cision, unless so d ATEMENT elease; distribution antermediates in the dds, including light of anaerobic bacter thways of anaerobic leveloped molecular thave enabled us to latic acid degradati have enabled us to lation of the compou sequenced, and cha comatic acid degrada molecular basis for mplished. 006 hnology, Aromatic C	ed in this report n official Department esignated by other n unlimited.	are those of the ment of the Army r documentation. The observation code f structurally vironmental pollutants, o the starting uction and fission. used to manipulate rium, <u>Rhodopseudomonas</u> ecifying two enzymes 4-hydroxybenzoate, latory gene required us, the first steps sion in the absence 15. NUMBER OF PAGES <u>4</u> 16. PRICE CODE
11. SUPPLEMENTARY NOTES The view, opinions and/ author(s) and should no position, policy, or de 12a. DISTRIBUTION/AVAILABILITY STA Approved for public re 13. ABSTRACT (Maximum 200 words) Aromatic acids are i diverse aromatic compound by many metabolic types compounds for central pa We have identified and d and clone genes for aroma palustris. These tools that initiate the degrad and we have also cloned, for the expression of ar towards elucidating the of oxygen have been acco 92.92.922 14. SUBJECT TERMS Biodegradation, Biotec 17. SECURITY CLASSIFICATION 18.	or findings contain t be construed as a cision, unless so d ATEMENT elease; distribution antermediates in the dds, including ligni of anaerobic bacter thways of anaerobic leveloped molecular thave enabled us to latic acid degradati have enabled us to lation of the compou sequenced, and cha omatic acid degrada molecular basis for mplished. 006 hnology, Aromatic C	ed in this report n official Department esignated by other n unlimited.	are those of the ment of the Army r documentation. The structurally vironmental pollutants, o the starting uction and fission. used to manipulate rium, <u>Rhodopseudomonas</u> ecifying two enzymes 4-hydroxybenzoate, latory gene required us, the first steps sion in the absence 15. NUMBER OF PAGES 4 16. PRICE CODE TION 20. LIMITATION OF ABSTRA
11. SUPPLEMENTARY NOTES The view, opinions and/ author(s) and should no position, policy, or de 12. DISTRIBUTION/AVAILABILITY STA Approved for public re 13. ABSTRACT (Maximum 200 words) Aromatic acids are i diverse aromatic compound by many metabolic types compounds for central pa We have identified and d and clone genes for arom palustris. These tools that initiate the degrad and we have also cloned, for the expression of ar towards elucidating the of oxygen have been acco 92.92.922 14. SUBJECT TERMS Biodegradation, Biotec 17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	or findings contain t be construed as a cision, unless so d ATEMENT elease; distribution antermediates in the dds, including light of anaerobic bacter thways of anaerobic leveloped molecular the enabled us to atic acid degradati have enabled us to ation of the compou sequenced, and cha omatic acid degrada molecular basis for mplished. 006 hnology, Aromatic O SECURITY CLASSIFICATION UNCLASSIFIED	ed in this report n official Department esignated by other n unlimited. biodegradation of n monomers and en- ia. They are also benzene ring redu- tools that can be on from the bacter identify genes spe- inds benzoate and of racterized a regu- tion enzymes. The benzene ring fiss of ABSTRACT UNCLASSIFIED	are those of the ment of the Army r documentation. The documentation. The documentation code f structurally vironmental pollutants, o the starting uction and fission. used to manipulate rium, <u>Rhodopseudomonas</u> ecifying two enzymes 4-hydroxybenzoate, latory gene required us, the first steps sion in the absence 15. NUMBER OF PAGES 4 16. PRICE CODE TION 20. LIMITATION OF ABSTRA UL

MOLECULAR BIOLOGY OF ANAEROBIC AROMATIC BIODEGRADATION

L

.

FINAL REPORT

CAROLINE S. HARWOOD

AUGUST 14, 1992

U. S. ARMY RESEARCH OFFICE DAAL03-89-K-0121

UNIVERSITY OF IOWA

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

Acusesion For
NULS GRADI
Brten Piel
Justi iention
B./
Distribution/
Availalitty Codos
Tav⊭ll sta/or Dist Special
A-1

DTIC QUALITY INSPECTED 3

A. STATEMENT OF THE PROBLEM STUDIED.

Chlorinated aromatic compounds and aromatic hydrocarbons, including toluene and xylene, comprise a large proportion of the toxic wastes that have been released into the environment. Under anaerobic conditions the aromatic carboxylic acids, benzoate and 4-hydroxybenzoate, are formed as key intermediates during the biodegradation of aromatic pollutants. These acids then enter central pathways of anaerobic benzene ring reduction and fission, leading to complete mineralization.

Not a single catabolic pathway for the anaerobic degradation of any aromatic compound has yet been worked out in detail, and the molecular basis for aromatic compound degradation by bacteria is even less well explored. If the potential of bacteria to degrade benzene rings under anaerobic conditions is to be manipulated to realize their full detoxification potential, or to produce intermediary compounds that may have commercial value, it will be necessary to understand in detail the metabolic mechanisms involved, to know how the pathways are regulated, and to develop approaches for modifying the genes encoding key enzymes.

As an approach to achieving these goals we have been studying the anaerobic degradation of two selected aromatic acids - benzoate and 4-hydroxybenzoate - by one bacterial species - *Rhodopseudomonas palustris*. Our emphasis has been on developing tools to explore the genetic basis of aromatic acid degradation. Our expectation is that it will be possible to extend many of our conclusions to other bacteria and to related compounds.

B. SUMMARY OF THE MOST IMPORTANT RESULTS.

Our most important contribution during the last three years has been the identification and development of molecular tools that can be used to clone and manipulate genes in *R. palustris*. These tools have enabled us to identify a regulatory gene, termed *aadR* (for anaerobic aromatic degradation regulator) which is required for the expression of genes involved in anaerobic 4-hydroxybenzoate and benzoate degradation. We have also obtained partial clones of the genes for benzoate-CoA ligase and aromatic acid-CoA ligase II, enzymes that catalyze the first steps in the degradation of benzoate and 4-hydroxybenzoate, respectively. Finally, we have made extensive use of immunoblot assays to identify environmental factors that are required for the regulated expression of benzoate-CoA ligase. With this work we have accomplished the first steps in elucidating the molecular basis for benzene ring fission in the absence of oxygen.

C. PUBLICATIONS.

Papers:

Gibson, J., J. F. Geissler, and C. S. Harwood. 1990. Benzoate-coenzyme A ligase from *Rhodopseudomonas palustris*. Methods in Enzymology (Hydrocarbons and methylotrophy) <u>188</u>:154-159.

- Kim, M-K., and C. S. Harwood. 1991. Regulation of benzoate-CoA ligase in *Rhodopseudomonas palustris*. FEMS Microbiol. Letts. <u>83</u>:199-204.
- Dispensa, M., C. T. Thomas, M.-K. Kim, J. A. Perrotta, J. Gibson, and C. S. Harwood. 1992. Anaerobic growth of *Rhodopseudomonas palustris* on 4-hydroxybenzoate is dependent on AadR, a member of the cyclic AMP receptor protein family of transcriptional regulators. J. Bacteriol. <u>174</u>: (in press).
- Gibson, J., and C. S. Harwood. Anaerobic utilization of aromatic carboxylates by bacteria. IN: Biological Degradation and Bioremediation Technology of Toxic Chemicals, R. Chaudhry, ed. (in press).

Published abstracts:

- Thomas, C., M. Dispensa, C. S. Harwood, and J. Gibson. 1990. Molecular analysis of anaerobic aromatic degradation by *Rhodopseudomonas palustris*. Abstr. Ann. Meet. Amer. Soc. Microbiol. <u>90</u>:K136.
- Thomas, C., M. Dispensa, M. K. Kim, J. A. Perrotta, J. Gibson, and C. S. Harwood. 1991. Molecular analysis of benzoate and 4-hydroxybenzoate photometabolism by *Rhodopseudomonas palustris*. VII International Symposium for Photosynthetic Prokaryotes.
- Dispensa, M., and C. S. Harwood. 1992. Identification of *aadR*, a regulatory gene required for anaerobic 4-hydroxybenzoate degradation by *Rhodopseudomonas* palustris. Abstr. Ann. Meet. Amer. Soc. Microbiol. <u>92</u>:K31.

D. SCIENTIFIC PERSONNEL SUPPORTED BY THIS PROJECT AND DEGREES AWARDED.

Marilyn Dispensa (Technician) Joseph Perrotta (Graduate Research Assistant) Min-Kyung Kim (Graduate Research Assistant) - M. S. awarded

E. REPORT OF INVENTIONS:

None