

# Nanotechnology Education at Oakland Community College

Tsung-Yu Pan, Ph.D. and Phillip D. Crockett

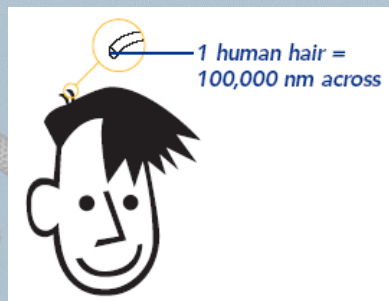
2900 Featherstone Road  
Auburn Hills, Michigan 48326

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## What is Nanoscale Science?

- The study of objects and phenomena at a very small scale, roughly 1 to 100 nanometers (nm) (U.S. National Nanotechnology Initiative: [www.nano.gov](http://www.nano.gov))
  - **10 hydrogen atoms** lined up measure about **1 nm**
  - A grain of sand is 1 million nm, or 1 millimeter, wide









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## Nanotechnology from our ancestors




**The First Nanotechnologists**

Ancient stained-glass makers knew that by putting varying, tiny amounts of gold and silver in the glass, they could produce the red and yellow found in stained-glass windows. Similarly, today's scientists and engineers have found that it takes only small amounts of a nanoparticle, precisely placed, to change a material's physical properties.

Gold particles in glass		Silver particles in glass	
<p>Size: 25 nm Shape: sphere Color reflected: <span style="color: red;">●</span></p> 	<p>Size: 100 nm Shape: sphere Color reflected: <span style="color: yellow;">●</span></p> 	<p>Size: 50 nm Shape: sphere Color reflected: <span style="color: green;">●</span></p> 	<p>Size: 40 nm Shape: sphere Color reflected: <span style="color: blue;">●</span></p> 
<p>Size: 100 nm Shape: sphere Color reflected: <span style="color: orange;">●</span></p> 	<p>Size: 100 nm Shape: prism Color reflected: <span style="color: red;">●</span></p> 	<p>Had medieval artists been able to control the size and shape of the nanoparticles, they would have been able to use the two metals to produce other colors. Examples:</p>	

Source: Dr. Chad A. Mirkin, Institute of Nanotechnology, Northwestern University      \*Approximate




The New York Times  
Images courtesy of the Stained Glass Museum, Britain


Community College, 1/26/2010

## Nanoparticles in Sunscreen Zinc Oxide (ZnO)

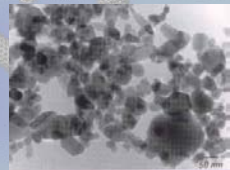
- **Large ZnO particles**
  - Block UV light
  - Scatter visible light
  - Appear white
- **Nanosized ZnO particles**
  - Block UV light
  - So small compared to the wavelength of visible light that they don't scatter it
  - Appear clear



"Traditional" ZnO sunscreen is white



Nanoscale ZnO sunscreen is clear



Zinc oxide nanoparticles

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# Anti-Bacterial

**Always Fresh™ containers**

IT'S ON TV

Nanotechnology keeps food fresher longer!

With... Without...

Always Fresh™ containers food lasts up to 50 days longer than ordinary plastic storage containers. Save money – food stays fresher longer, so you throw away less. Made with nanotechnology, containers include silver nanoparticles – naturally antibacterial and help prevent the growth of mold and fungus. Great for fruits, vegetables, herbs, cheeses, soups, sauces, meats and more. Keeps bread soft and cookies and crackers crisp. Set of five plus lids. Plastic. 29634 Always Fresh™ Containers were \$19.99, Sale! \$9.98

**SilvaSorb™**  
SILVER ANTIMICROBIAL DRESSING  
SUSTAINED-RELEASE, SUPER-ABSORBENT

Reorder: MSC9322  
NDC: 08327-310-89  
Sterile Unless Opened or Damaged

2" x 2" Sheet  
Single use only.

**INDICATIONS:**  
SilvaSorb Silver Antimicrobial Dressing is an effective barrier to bacterial penetration and is effective against a broad range of micro-organisms. The barrier function of the dressing may help reduce infection in partial and full thickness wounds including pressure ulcers, venous stasis ulcers, diabetic ulcers, first and second degree burns, abrasions and lacerations, donor sites and surgical wounds. SilvaSorb may be used over debrided and grafted partial thickness wounds.

**DIRECTIONS:**  
1. Cleanse the wound using saline or Skintegrity Wound Cleanser.  
2. Remove SilvaSorb from its pouch and two inner liners and place it in contact with the wound base, either side down.  
3. If SilvaSorb is too large for the wound, then the dressing may be cut to an appropriate size for the application.  
4. Secure with an appropriate secondary dressing and change as necessary.  
NOTE: SilvaSorb may remain in place for up to 7 days. However, dressing change frequency will depend on the type or condition of the wound. See insert for further information. • Store at room temperature.

www.medline.com SilvaSorb is a trademark of AcryMed, Inc.,  
Patents Pending. Manufactured in USA for Medline Industries, Inc.,  
Mundelein, IL 60060 USA 1-800-MEDLINE 8002ACM

Ag

0 80196 174366 0



Electrolytic silver nanoparticles (Ag<sup>+</sup>), removes 99.9% of harmful germs without having to wash clothes in hot water

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## NanoSphere® on Natural Fibers

## Spill resistance fabric

- Stain protection, oil and water repellence and washing permanence at the highest level (by Schoeller)



**YOUR CHOICE**  
**\$19.99**  
3XL-5XL \$22.99

**NANO-tex Fabric**

This NANO-TEX™ fabric uses nanotechnology to provide amazing spill resistance. You get look great and stay comfortable, all day long.

**RedHead® Short-Sleeve Nano-Text™ Twill Shirt**  
60221903

Levi Strauss

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## Environment: Paint That Cleans Air

- **Nanopaint on buildings could reduce pollution**
  - When exposed to ultraviolet light, titanium dioxide ( $\text{TiO}_2$ ) nanoparticles in paint break down organic and inorganic pollutants that wash off in the rain
  - Decompose air pollution particles like formaldehyde



Buildings as air purifiers?

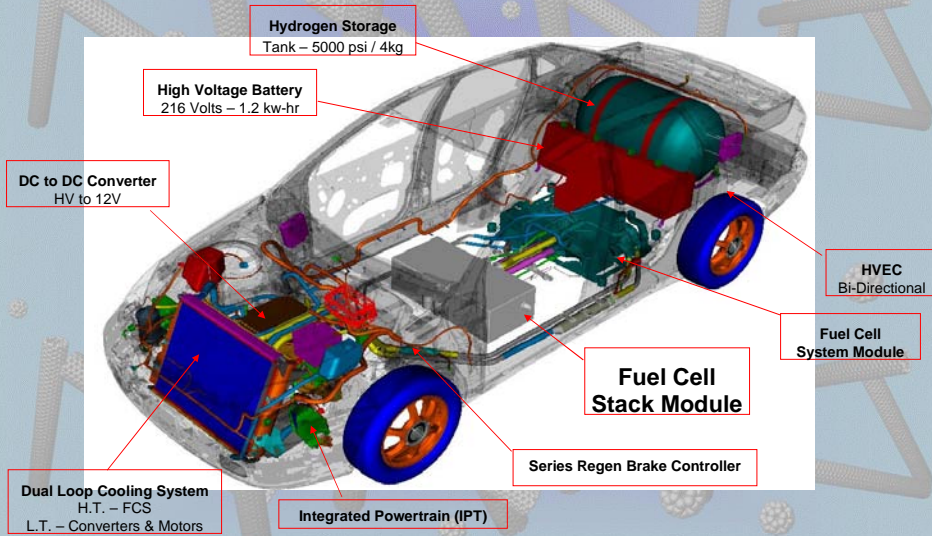
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## Energy: Li-ion Batteries



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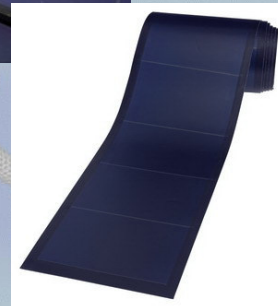
## Energy: Fuel Cell (Ford Focus)



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## Energy: Solar Cells

**UNI-SOLAR.**  
United Solar Ovonic



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# Carbon-Nanotube Based Display

**NANOTECH**

**CNT Electrode**

**The first commercial Product that brings Nanoscale electronics Into the middle class Home.**

**ON DISPLAY**

**Samsung Advanced Institute of Technology**

14.3" Color e-Paper

Please do not touch!

60 TECHNOLOGY EDGE November 2006

www.technology.com

www.technology.com

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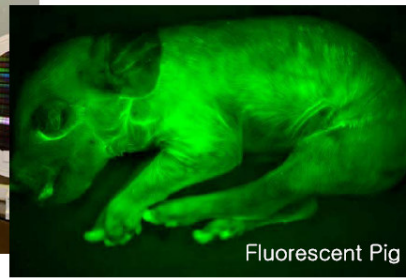
- **Technology**

- Better data storage and computation



- **Health Care**

- Chemical and biological sensors, drugs and delivery devices



Thin layers of gold are used in tiny medical devices

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## Nanotechnology Occupation Projections Southeast Michigan, 2009-2019

- The **Economic Modeling Specialists' (EMSI)** database was used to gather data.
- EMSI provides integrated regional economic and labor market data and specializes in detailed information about regional economies for assessment and planning purposes.
- The database provides information regarding industry, workforce, and education.
- Spring 2009 data was used.

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## Required Educational Level

- **Associate Degree**
  - Biological, chemical, electrical and electronic engineering, engineering, and industrial technician positions
- **Bachelor Degree**
  - Electrical engineers, chemists, chemical engineers, materials engineers, biomedical engineers, biological scientists
- **Master Degree**
  - Operations research analysts
- **Doctoral Degree**
  - Biochemists, biophysicists, microbiologists

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## Micro/Nanotechnology Industries

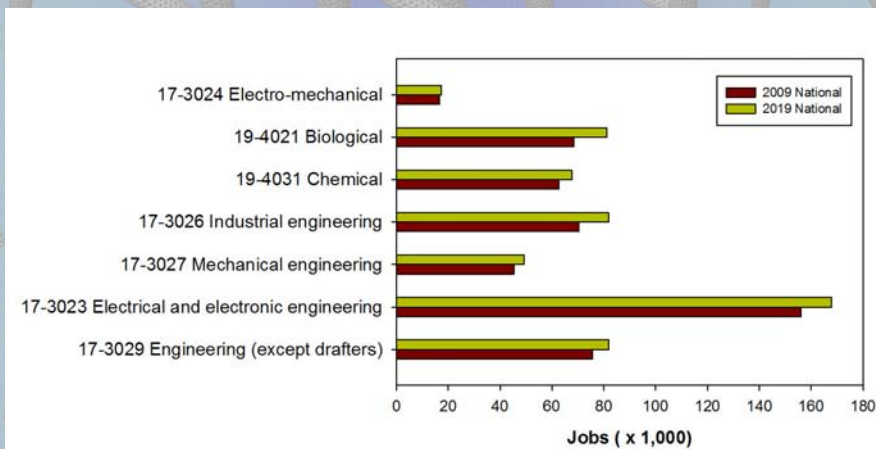
- Aerospace
- Agricultural
- Chemical
- Electronics
- Energy
- Environmental
- Information Technology/Telecommunications
- Manufacturing
- Materials
- Medical/Pharmaceuticals/Healthcare
- Semiconductor
- Textiles
- Universities/Educational Institutions

(Source: <http://www.workingin-nanotechnology.com>)

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## Nanotechnology Occupation Projections Technicians 2009-2019

- **National**

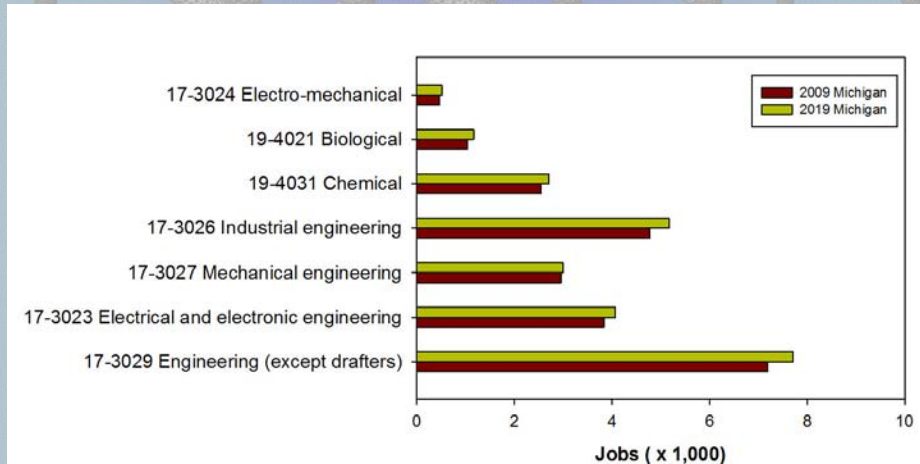


- **Steady and growing industries!**

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## Nanotechnology Occupation Projections Technicians 2009-2019

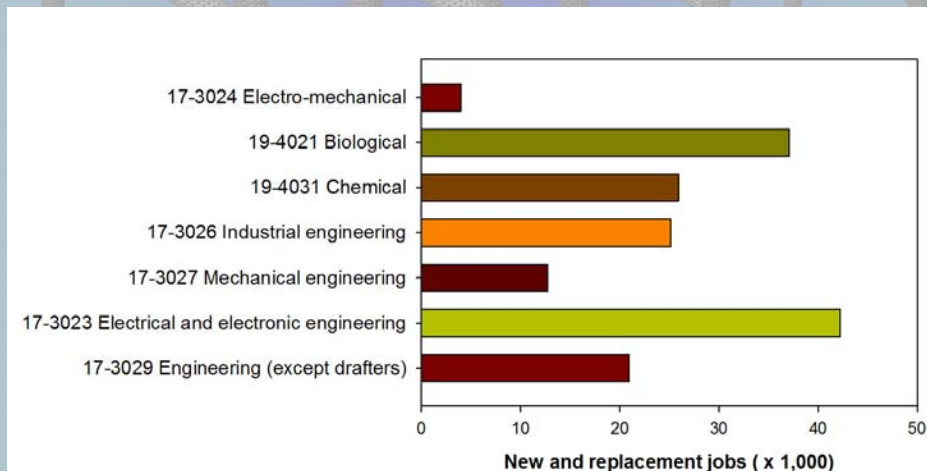
- **State of Michigan**



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## Nanotechnology Occupation Projections Technicians 2009-2019 New and Replacement Jobs

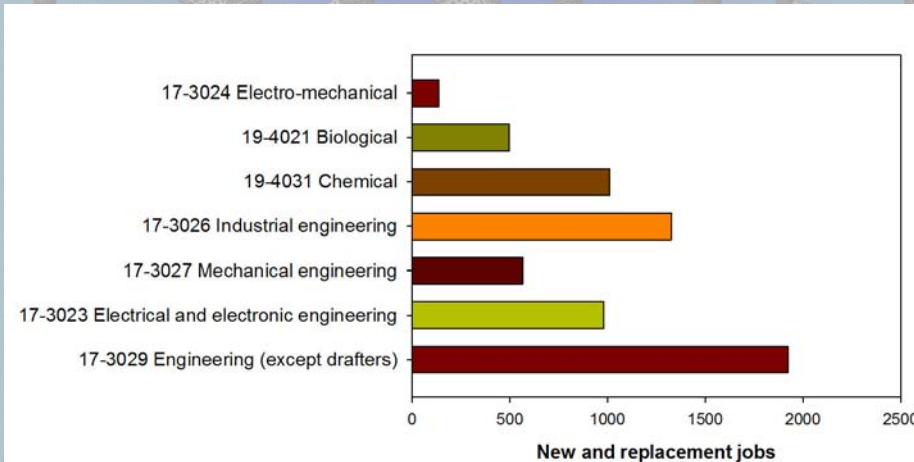
- **National**



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# Nanotechnology Occupation Projections Technicians 2009-2019 New and Replacement Jobs

- **State of Michigan**



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## Nanotechnology Career Pathway

### Associate Degrees

17-3029 Engineering technicians  
17-3023 Electrical and electronic engineering technicians  
17-3027 Mechanical engineering technicians  
17-3026 Industrial engineering technicians  
19-4031 Chemical technicians  
19-4021 Biological technicians  
17-3024 Electro-mechanical technicians

2009 average hourly earning

**\$24**

### Bachelor Degrees

17-2071 Electrical engineers  
19-2031 Chemists  
**17-2131 Materials engineers**  
17-2041 Chemical engineers  
17-2031 Biomedical engineers  
19-1029 Biological scientists  
19-2032 Materials scientists

**\$34**

- **Materials engineers earn >\$40/hour!**

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## Nanotechnology in Materials Science Associate in Applied Science at OCC

<u>Major Requirements</u>	<u>Credits</u>
NNO 1000 Introduction to Nanoscience .....	3
NNO 1050 Structural Properties of Materials .....	4
NNO 1500 Nanotechnology and Society .....	3
NNO 2500 Nanotechnology Internship .....	3
or	
NNO 2550 Practical Applications of Nanotechnology Characterization .....	3
<i>Students must select three from following four courses</i>	
NNO 1100 Nanotech Applications - Metals .....	4
NNO 1200 Nanotechnology and Advanced Batteries .....	4
NNO 2200 Nanotech Applications - Plastics .....	4
NNO 2300 Nanotech Applications - Ceramics.....	3

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## Nanotechnology in Materials Science Associate in Applied Science at OCC

<u>Required Supportive Courses</u>	<u>Credits</u>
MSE 1000 Metallurgy.....	3
MSE 1100 Metallography .....	3
BIO 1530• Introductory Biology: Molecular and Cellular.....	4
CHE 1510• General Chemistry I.....	4
ENG 14501• Writing & Reading for Problem Solving .....	3
MAT 11002 Elementary Algebra .....	4
PSC 15603• Physical Science I .....	4
or	
PHY 16103• College Physics I .....	4
or	
APP 21703 Applied Technology .....	4
SPE 1290• Interpersonal Communication.....	3
or	
SPE 1610• Fundamentals of Speech .....	3

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**Projections for Oakland County, Michigan (26125)**

SOC Code	Description	2009 Jobs	2019 Jobs	Change	% Change	New & Rep. Jobs	% New & Rep.	2009 Average Hourly Earnings	Education Level
51-9011	Chemical equipment operators and tenders	222	252	30	14%	89	40%	\$21.68	Moderate-term on-the-job training
51-8091	Chemical plant and system operators	149	190	41	28%	105	71%	\$24.93	Long-term on-the-job training
17-3029	Engineering technicians, except drafters, all other	1,453	1,654	201	14%	484	33%	\$30.28	Associate's degree
17-3023	Electrical and electronic engineering technicians	922	1,028	106	11%	286	31%	\$23.83	Associate's degree
17-3027	Mechanical engineering technicians	955	1,013	58	6%	244	26%	\$26.31	Associate's degree
17-3026	Industrial engineering technicians	980	1,012	32	3%	223	23%	\$26.71	Associate's degree
19-4031	Chemical technicians	283	360	77	27%	171	61%	\$22.15	Associate's degree
19-4021	Biological technicians	93	109	16	17%	49	53%	\$19.04	Associate's degree
17-3024	Electro-mechanical technicians	119	130	11	9%	34	29%	\$29.32	Associate's degree
17-2071	Electrical engineers	1,410	1,469	59	4%	386	27%	\$37.35	Bachelor's degree
19-2031	Chemists	240	304	64	27%	128	53%	\$29.11	Bachelor's degree
17-2131	Materials engineers	282	319	37	13%	103	36%	\$44.36	Bachelor's degree
17-2041	Chemical engineers	199	231	32	16%	83	41%	\$39.12	Bachelor's degree
17-2031	Biomedical engineers	87	95	8	9%	28	32%	\$34.42	Bachelor's degree
19-1029	Biological scientists, all other	28	31	3	11%	9	31%	\$28.55	Bachelor's degree
19-2032	Materials scientists	13	13	0	0%	3	26%	\$32.59	Bachelor's degree
15-2031	Operations research analysts	814	866	52	6%	215	26%	\$41.96	Master's degree
19-1022	Microbiologists	25	26	1	4%	6	24%	\$29.54	Doctoral degree
19-1021	Biochemists and biophysicists	20	19	(1)	(5%)	3	15%	\$34.89	Doctoral degree
		<b>8,294</b>	<b>9,121</b>	<b>827</b>	<b>11%</b>	<b>2,649</b>	<b>36%</b>	<b>\$32.01</b>	

Source: EMSI Covered Employment - Spring 2009

### Projections for Southeast Michigan

Counties: Genesee, Michigan (26049), Lapeer, Michigan (26087), Livingston, Michigan (26093), Macomb, Michigan (26099), Oakland, Michigan (26125), St. Clair, Michigan (26147), Washtenaw, Michigan (26161), Wayne, Michigan (26163)

SOC Code	Description	2009		2019		% Change	% New & Rep.	Jobs	% New & Rep.	2009 Average	
		Jobs	Jobs	Jobs	Jobs					Hourly Earnings	Hourly Earnings
51-9011	Chemical equipment operators and tenders	595	632	37	6%	196	33%	\$21.41	Moderate-term on-the-job training		
51-8091	Chemical plant and system operators	406	464	58	14%	232	57%	25.23	Long-term on-the-job training		
17-3029	Engineering technicians, except drafters, all other	5,799	6,196	397	7%	1,528	26%	30.22	Associate's degree		
17-3026	Industrial engineering technicians	2,987	3,119	132	4%	715	24%	25.00	Associate's degree		
17-3023	Electrical and electronic engineering technicians	2,221	2,326	105	5%	538	24%	23.83	Associate's degree		
19-4031	Chemical technicians	897	1,000	103	11%	403	45%	18.92	Associate's degree		
17-3027	Mechanical engineering technicians	2,100	2,063	(37)	(2%)	373	18%	24.59	Associate's degree		
19-4021	Biological technicians	577	656	79	14%	285	49%	18.39	Associate's degree		
17-3024	Electro-mechanical technicians	311	343	32	10%	93	30%	29.47	Associate's degree		
17-2071	Electrical engineers	3,836	3,793	(43)	(1%)	848	22%	37.61	Bachelor's degree		
19-2031	Chemists	979	1,102	123	13%	382	39%	28.01	Bachelor's degree		
17-2041	Chemical engineers	557	613	56	10%	198	35%	35.53	Bachelor's degree		
17-2131	Materials engineers	645	680	35	5%	185	29%	40.02	Bachelor's degree		
17-2031	Biomedical engineers	208	238	30	14%	77	37%	34.17	Bachelor's degree		
19-1029	Biological scientists, all other	241	246	5	2%	54	22%	27.84	Bachelor's degree		
19-2032	Materials scientists	60	68	8	13%	24	40%	33.12	Bachelor's degree		
15-2031	Operations research analysts	1,783	1,855	72	4%	430	24%	40.42	Master's degree		
19-1022	Microbiologists	114	124	10	9%	33	29%	26.95	Doctoral degree		
19-1021	Biochemists and biophysicists	80	94	14	18%	30	38%	30.56	Doctoral degree		
		<b>24,396</b>	<b>25,612</b>	<b>1,216</b>	<b>8%</b>	<b>6,624</b>	<b>33%</b>	<b>\$30.63</b>			

Source: EMSI Covered Employment - Spring 2009

## Projections for State of Michigan

SOC Code	Description	State 2009		State 2019		State % Change		State New & Rep. Jobs		State % New & Rep.		2009 State Average		Education Level
		1,324	892	1,409	1,055	6%	18%	439	547	33%	61%	Hourly Earnings		
51-9011	Chemical equipment operators and tenders	1,324	892	1,409	1,055	6%	18%	439	547	33%	61%	\$22.00	\$24.13	Moderate-term on-the-job training
51-8091	Chemical plant and system operators	892	7,195	1,055	7,713	18%	7%	547	1,922	61%	27%	\$24.13	\$28.44	Long-term on-the-job training
17-3029	Engineering technicians, except drafters, all other	7,195	4,778	7,713	5,172	7%	8%	1,922	1,326	27%	28%	\$28.44	\$23.46	Associate's degree
17-3026	Industrial engineering technicians	4,778	2,551	5,172	2,708	8%	6%	1,326	1,010	28%	40%	\$23.46	\$18.66	Associate's degree
19-4031	Chemical technicians	2,551	3,837	2,708	4,068	6%	6%	1,010	980	40%	26%	\$18.66	\$24.14	Associate's degree
17-3023	Electrical and electronic engineering technicians	3,837	2,954	4,068	2,944	6%	(0%)	980	566	26%	19%	\$24.14	\$23.92	Associate's degree
17-3027	Mechanical engineering technicians	2,954	1,042	2,944	1,168	(0%)	12%	566	498	19%	48%	\$23.92	\$17.20	Associate's degree
19-4021	Biological technicians	1,042	471	1,168	517	12%	10%	498	138	48%	29%	\$17.20	\$28.87	Associate's degree
17-3024	Electro-mechanical technicians	471	5,574	517	5,590	10%	0%	138	1,310	29%	24%	\$28.87	\$36.11	Bachelor's degree
17-2071	Electrical engineers	5,574	2,075	5,590	2,207	0%	6%	1,310	681	24%	33%	\$36.11	\$30.23	Bachelor's degree
19-2031	Chemists	2,075	908	2,207	1,016	6%	12%	681	339	33%	37%	\$30.23	\$36.96	Bachelor's degree
17-2041	Chemical engineers	908	922	1,016	985	12%	7%	339	278	37%	30%	\$36.96	\$38.26	Bachelor's degree
17-2131	Materials engineers	922	293	985	340	7%	16%	278	114	30%	39%	\$38.26	\$33.01	Bachelor's degree
17-2031	Biomedical engineers	293	457	340	449	16%	(2%)	114	85	39%	19%	\$33.01	\$28.07	Bachelor's degree
19-1029	Biological scientists, all other	457	110	449	122	(2%)	11%	85	41	19%	37%	\$28.07	\$33.73	Bachelor's degree
19-2032	Materials scientists	110	2,140	122	2,213	11%	3%	41	503	37%	23%	\$33.73	\$39.42	Bachelor's degree
15-2031	Operations research analysts	2,140	164	2,213	192	3%	17%	503	61	23%	37%	\$39.42	\$32.59	Master's degree
19-1021	Biochemists and biophysicists	164	213	192	227	17%	7%	61	57	37%	27%	\$32.59	\$26.23	Doctoral degree
19-1022	Microbiologists	213	37,900	227	40,095	7%	8%	57	10,895	27%	32%	\$26.23	\$30.30	Doctoral degree
		<b>37,900</b>	<b>40,095</b>	<b>8%</b>	<b>32%</b>	<b>10,895</b>	<b>\$30.30</b>							

Source: EMSI Covered Employment - Spring 2009

## National Projections

SOC Code	Description	National 2009	National 2019	National % Change	National New & Rep. Jobs	National % New & Rep.	2009 National Median Hourly Earnings	Education Level
51-9011	Chemical equipment operators and tenders	52,718	53,393	1%	14,769	28%	\$21.27	Moderate-term on-the-job training
51-8091	Chemical plant and system operators	47,545	45,675	(4%)	18,571	39%	\$24.50	Long-term on-the-job training
17-3023	Electrical and electronic engineering technicians	156,040	167,814	8%	42,213	27%	\$25.23	Associate's degree
19-4021	Biological technicians	68,543	81,177	18%	37,072	54%	\$19.35	Associate's degree
19-4031	Chemical technicians	62,678	67,655	8%	25,926	41%	\$20.39	Associate's degree
17-3026	Industrial engineering technicians	70,372	81,803	16%	25,160	36%	\$24.72	Associate's degree
17-3029	Engineering technicians, except drafters, all other	75,693	81,881	8%	20,954	28%	\$26.79	Associate's degree
17-3027	Mechanical engineering technicians	45,322	49,240	9%	12,760	28%	\$23.70	Associate's degree
17-3024	Electro-mechanical technicians	16,537	17,308	5%	3,998	24%	\$23.13	Associate's degree
17-2071	Electrical engineers	145,443	159,204	9%	47,530	33%	\$39.47	Bachelor's degree
19-2031	Chemists	77,125	83,291	8%	26,560	34%	\$32.94	Bachelor's degree
17-2041	Chemical engineers	29,761	32,625	10%	10,427	35%	\$40.50	Bachelor's degree
17-2031	Biomedical engineers	17,672	21,857	24%	8,208	46%	\$38.27	Bachelor's degree
17-2131	Materials engineers	22,475	25,213	12%	7,972	35%	\$37.90	Bachelor's degree
19-1029	Biological scientists, all other	28,581	30,586	7%	7,810	27%	\$31.85	Bachelor's degree
19-2032	Materials scientists	10,509	11,780	12%	4,050	39%	\$37.47	Bachelor's degree
15-2031	Operations research analysts	60,665	66,519	10%	18,032	30%	\$34.44	Master's degree
19-1021	Biochemists and biophysicists	20,359	23,963	18%	7,739	38%	\$41.00	Doctoral degree
19-1022	Microbiologists	15,617	17,584	13%	5,139	33%	\$31.94	Doctoral degree
		<b>1,023,655</b>	<b>1,118,568</b>	<b>10%</b>	<b>344,890</b>	<b>34%</b>	<b>\$32.30</b>	

Source: EMSI Covered Employment - Spring 2009

## Contacts

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