U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Webinar: What's New with the Algae Technology Educational Consortium

Ira Levine, Ph.D.

President and Board Chair

Algae Foundation

May 20, 2021

Webinar Housekeeping

- Attendees will be in listen-only mode
- Audio connection options:
  - Computer audio
  - Dial in through your phone (best connection)
- Technical difficulties? Contact us through the chat section, lower right of your screen
- Use the Q&A window to ask questions
- Today's webinar will be recorded and posted to "BETO Webinars": energy.gov/eere/bioenergy/beto-webinars

About the Bioenergy Communicators (BioComms) Working Group

Sponsor:

- U.S. Department of Energy (DOE) Bioenergy Technologies Office (BETO)

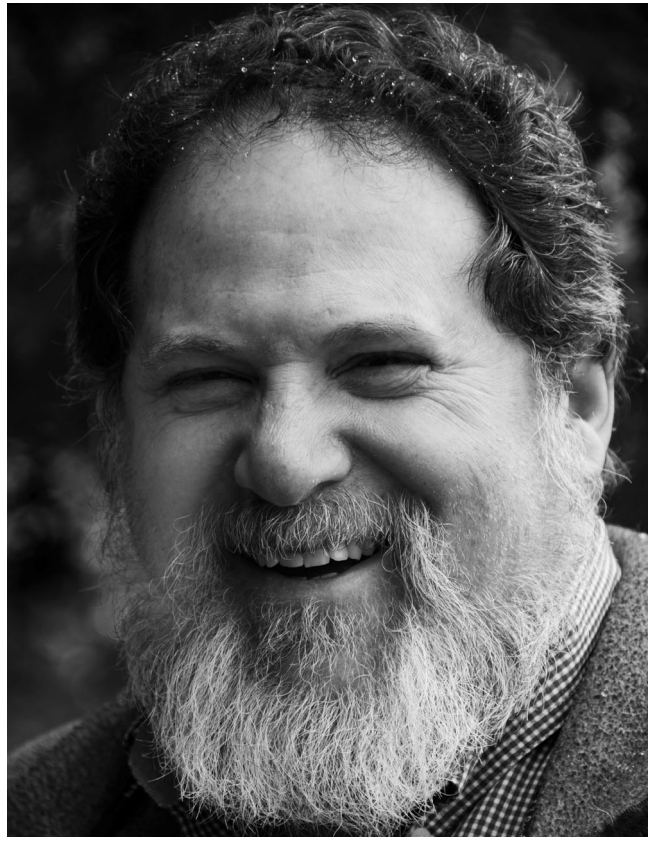
BETO & DOE National Laboratory Members:

- Bioenergy communicators, laboratory relationship managers, BETO tech team team, and education and workforce development professionals

Purpose:

- Communications strategy for BETO-funded bioenergy research and development

Photo by iStock



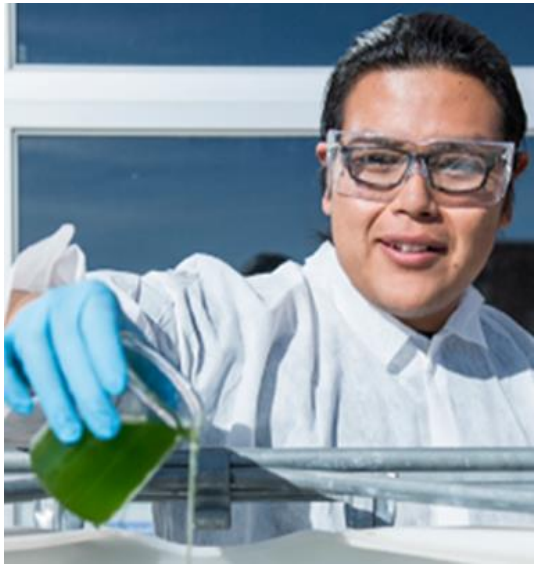
Ira “Ike” Levine, Ph.D.

President and Board Chair

Algae Foundation

ATEC ALGAE TECHNOLOGY EDUCATIONAL CONSORTIUM

What's New with the Algae Technology Educational Consortium



Ira "Ike" Levine, Ph.D.
University of Southern Maine
Algae Foundation

Bioenergy Technologies Office
BioComms Working Group

May 20, 2021

www.thealgaefoundation.org
www.algaefoundationatec.org

- Health Creams
- Lotion Additives
- Toothpaste
- Shampoo & Conditioners
- Facial Masques
- Clarifiers and Toners
- Cosmetics

COSMETICS & BEAUTY PRODUCTS

- Anti-coagulants
- Coagulants
- Agar Petrie Dishes
- Sterilizing Agents
- Iodine
- Laxatives
- Emollients

PHARMA & MEDICAL APPLICATIONS

- Protein Supplements
- Vitamin Supplements
- Blood Thinners
- DHA & EPA
- Omega-3 and Omega-6 Fatty acids

NEUTRICEUTICALS & DIETARY SUPPLEMENTS

- Bioplastics & Biopaper
- Paper Stabilizers
- Marbling Techniques
- Decorative Papers and Wall Papers
- Paper adhesives & Temporary Glue
- Textile fibers and additives

PACKAGING & BIOPLASTICS

- Wastewater treatment
- Phosphorus and nitrogen removal
- Soil amendment as fibrous material
- Manure Processing and Soil Reclamations

SOIL & WATER TREATMENT/ RECLAMATION

- Bio-oil
- JP8 (Jet Fuel)
- Kerosene
- Ethanol
- Biodiesel
- Green Diesel
- Biomethane
- Biogasoline

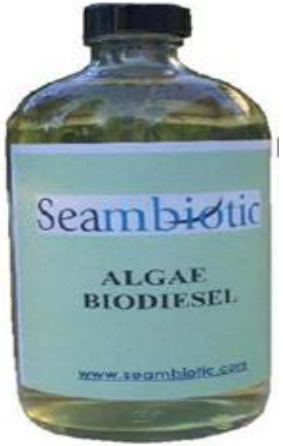
BIOFUELS

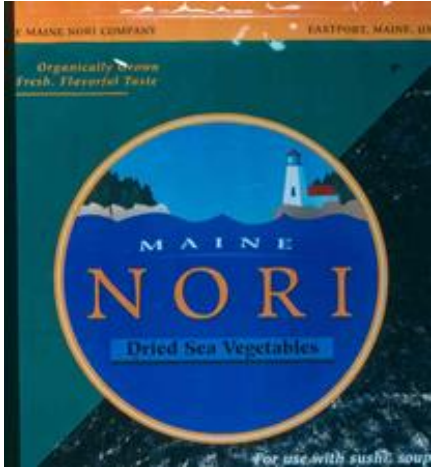
- Domestic Animal Food supplement
- Protein Additive
- Livestock Pure Food
- Fish Food and Vitamin Supplement
- Flea and Tick Control

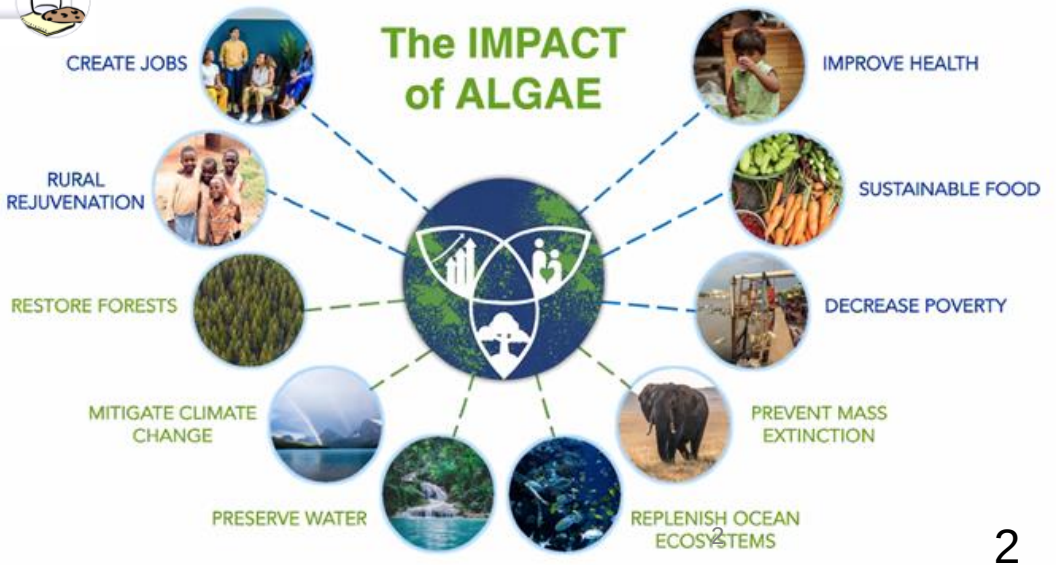
PET FOOD & FERTILIZERS

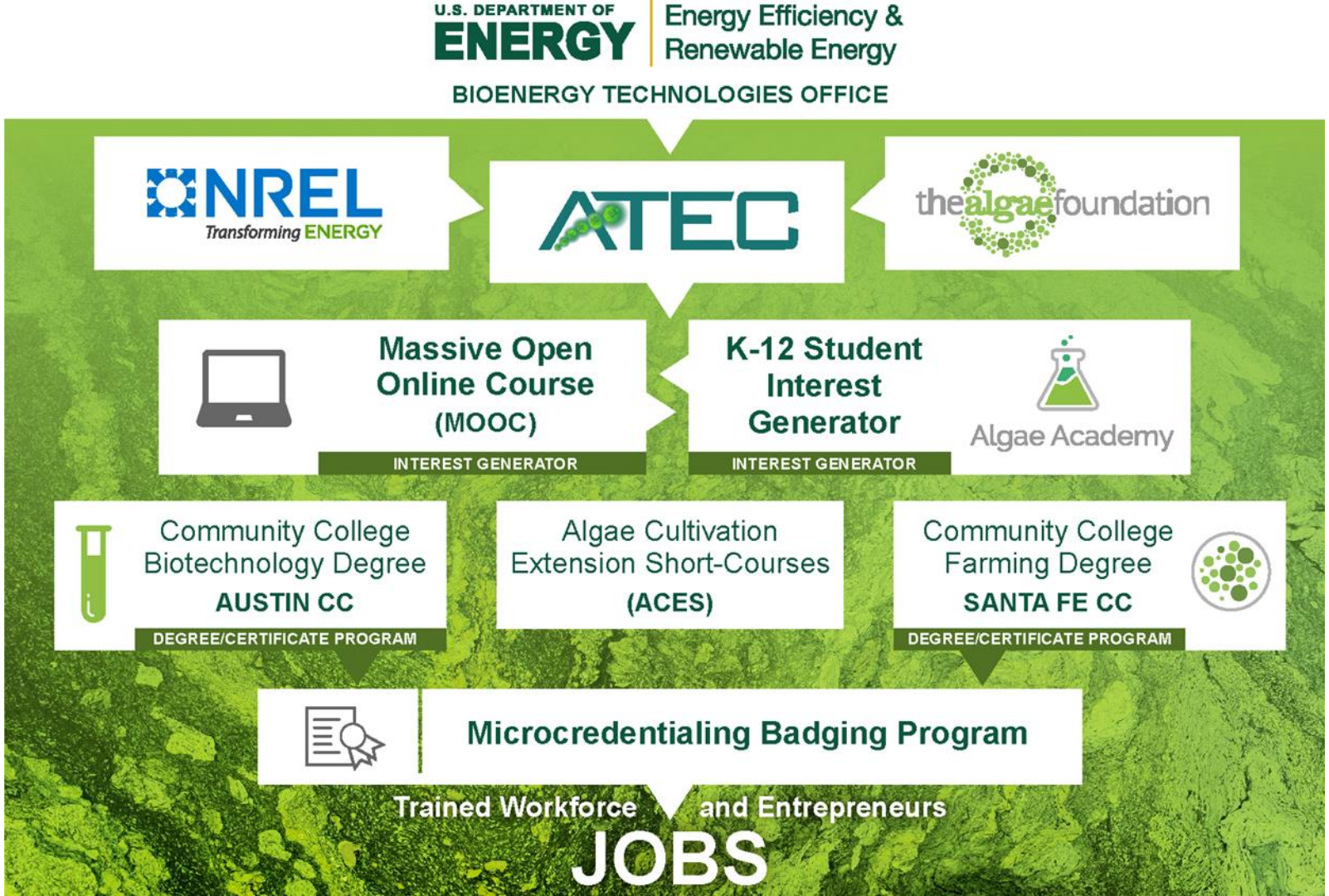
- Cooking Oils
- Protein Bars & Supplements
- Algal Flours & "Grains"
- Baby Formula
- Thickeners & Coagulants
- Gelling Agents

FOOD & SNACKS








U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy
BIOENERGY TECHNOLOGIES OFFICE
NREL
Transforming ENERGY
ATEC
thealgaefoundation
Massive Open Online Course (MOOC)
INTEREST GENERATOR
K-12 Student Interest Generator
INTEREST GENERATOR
Algae Academy
Community College Biotechnology Degree
AUSTIN CC
DEGREE/CERTIFICATE PROGRAM
Algae Cultivation Extension Short-Courses
(ACES)
Community College Farming Degree
SANTA FE CC
DEGREE/CERTIFICATE PROGRAM
Microcredentialing Badging Program
Trained Workforce and Entrepreneurs
JOBS

Algae Academy

Overview

5-Day Curriculum for grades K-12

- Algae 101 – basic and applied
- Cultivation
- Sampling
- Microscopy
- Data Visualization and Analysis
- Entrepreneurship
- Kits are “drop-in” ready, delivered to the schools
- Aligned with National NGSS
- Free to all schools & teachers who apply, AY 2021-2022 application available in June 2021

Algae Academy History

	Prior Algae Knowledge	After Algae Knowledge	Prior Algae Interest	After Algae Interest
Mean	1.66 ± 0.15	4.13 ± 0.14	2.56 ± 0.25	4.22 ± 0.11

Algae Academy

EDUCATING STUDENTS ON THE POWER OF ALGAE

In March 2020 the Algae Academy attended the San Diego Festival of Science and Engineering, a family STEM event.

We gave Algae Academy “Mini-Kits” to over 1,000 families so they could grow algae at home!
The kits included:

- 50mL Culture Flask
- Algae, salts, nutrients
- Secchi Stick
- Protocol and info on Algae Academy
- Bookmark to share with their teachers about what they were up to!

Families were also able to look at algae under the microscope and learn more about the power of algae!

Summer Algae Science Institute

ALGAL BASED EDUCATOR TRAINING

2021 SASI Updates

- SASI transitioned from 5-day workshops with teachers and students to 2-day professional workshops preparing teachers to teach the Algae Academy in their classrooms.
  - Shorter trainings allow for more SASI sessions.
  - Shorter sessions are easier for teachers to attend.
  - Removing student participation allows for more in-depth training of teachers.
- Partnering with ATEC community colleges and local STEM education programs.
- Two sessions to be facilitated by Algae Academy alumni teachers!

A Modesto City School

JAMES C. ENOCHS HIGH SCHOOL

3201 Sylvan Avenue, Modesto, CA 95355
(209) 574-1719 •Fax: (209) 574-1720
http://enochs.mcs4kids.com

ATEC member school

ATEC and Waianae High School, Hawaii
Limu culture

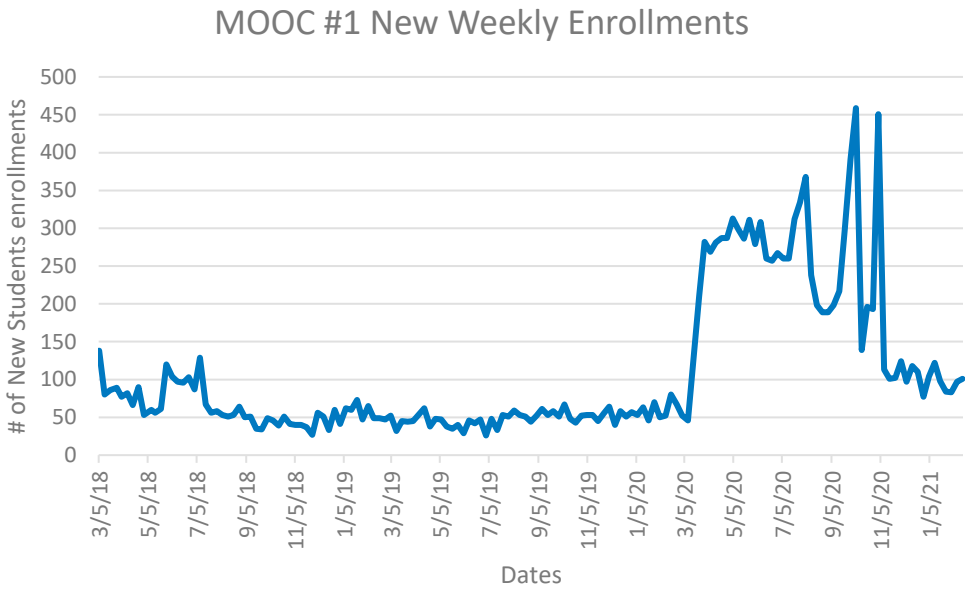
Algae Massive Open Online Courses (Algae MOOCs)

Introduction to Algae MOOC #1

- 17859 students (98% approval rating)
- 10% received a pay increase or promotion
- 43% received a tangible career benefit from this course

Algae Biotechnology MOOC #2

- 1937 students



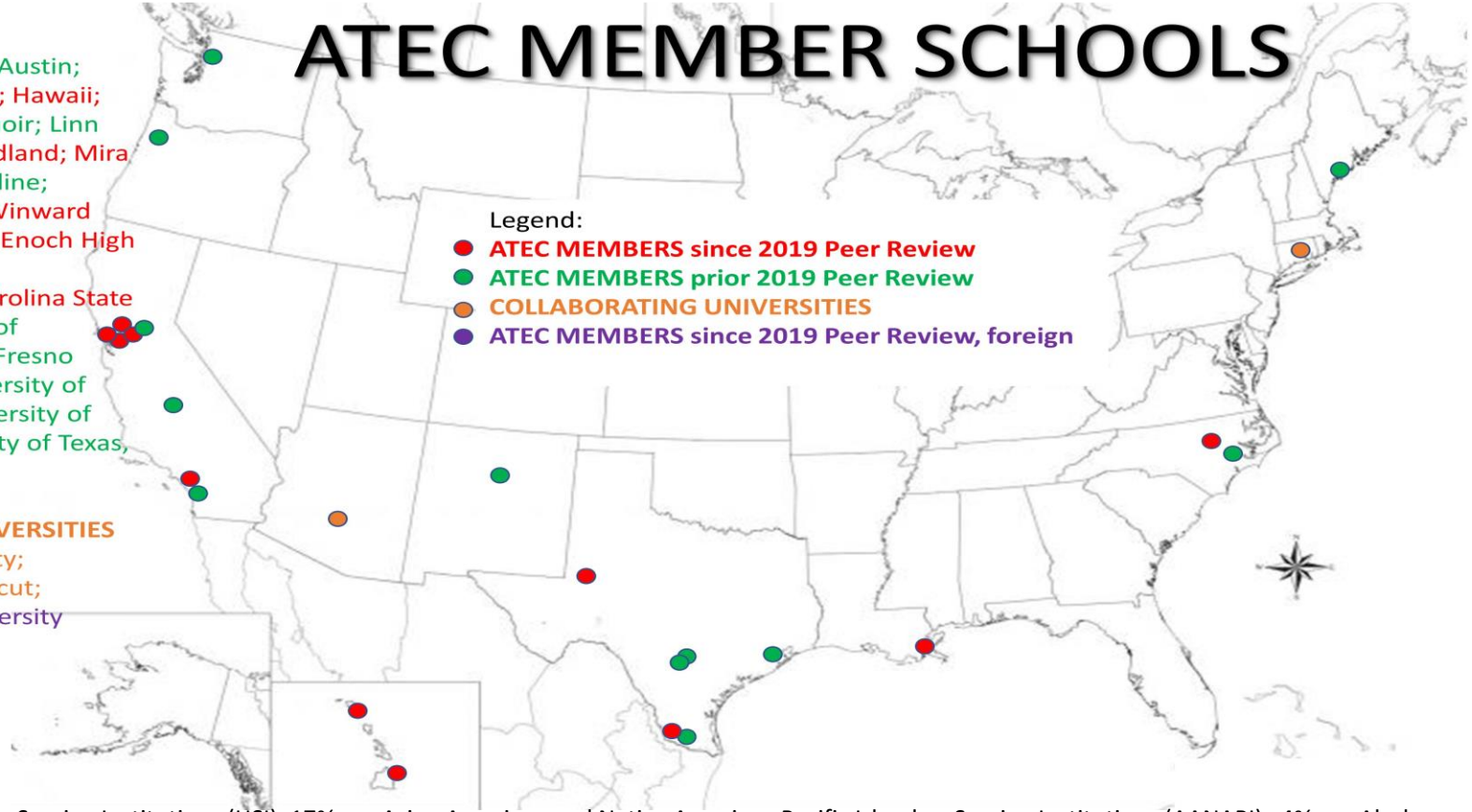
MOOC # 3 Introduction to Seaweed Biotechnology (production stage)

MOOC # 4 Algae New Products and Polymers (developmental stage)

ATEC MEMBER SCHOOLS

ATEC MEMBERS
Community Colleges: Austin; Contra Costa; Delgado; Hawaii; Laney; Las Positas; Lenoir; Linn Benton; Lone Star; Midland; Mira Costa; Santa Fe; Shoreline; Solano; South Texas; Winward
High School: James C. Enoch High School
Universities: North Carolina State University; University of California, San Diego; Fresno State University; University of Southern Maine; University of Texas, Austin; University of Texas, Rio Grande Valley

COLLABORATING UNIVERSITIES
Arizona State University;
University of Connecticut;
Incheon National University

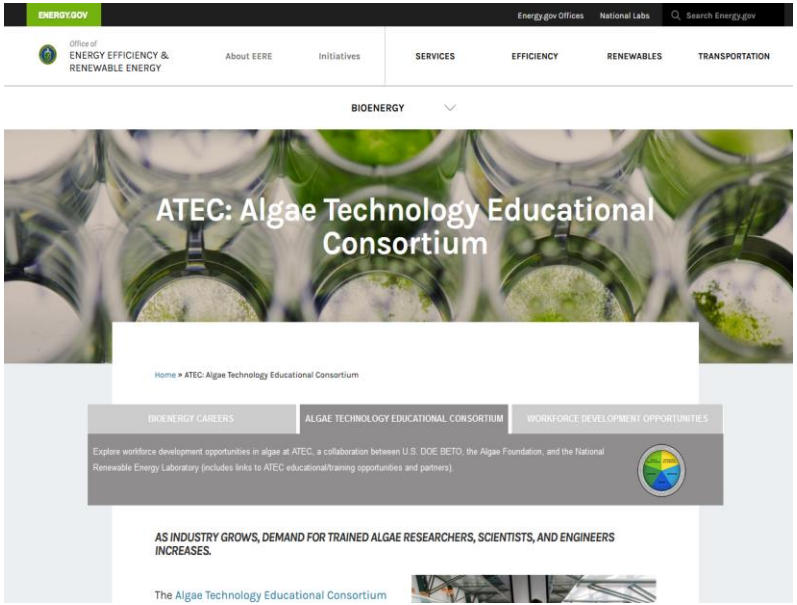


43% are designated Hispanic Serving Institutions (HSI), 17% are Asian American and Native American Pacific Islander- Serving Institutions (AANAPI), 4% are Alaska Native-Serving and Native Hawaiian-Serving Institutions (ANNH), 4% are Predominantly Black Institutions (PBI), and 4% are Historically Black Colleges and Universities (HBCU).

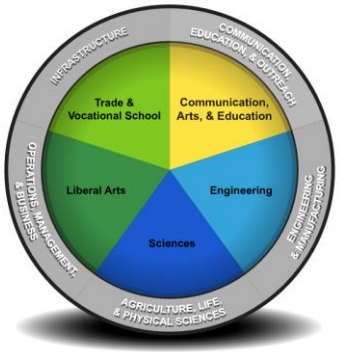
Premier Program for BETO's Education and Workforce Development

- Promote ATEC program on BETO's website and Career Exploration Wheel
- Disseminate ATEC progress
  - 7 publications and 41 presentations
  - Social Media (~5000 friends, followers, members)

Twitter LinkedIn Instagram Facebook



Career Exploration Wheel

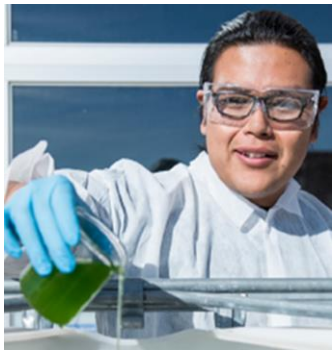


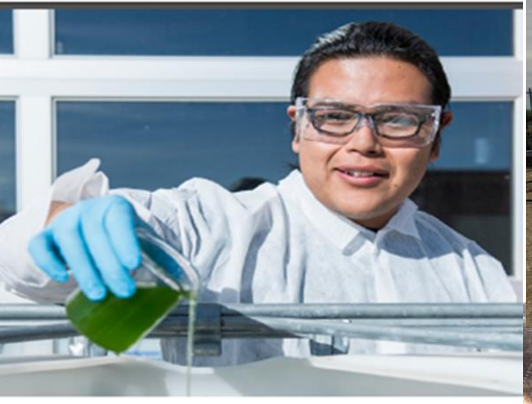
https://www.energy.gov/eere/bioenergy/atec-algae-technology-educational-consortium

Algae Cultivation

Community College Certificate Degree Program

- 250 participating students (cumulative - 5 years)
- Recruitment of graduates by algal farms
- Conversion from in-person courses to online format (5 classes)
- Development of heterotrophic cultivation curriculum (Academic Year 2021-2022)
- Initiate seaweed cultivation curriculum development (Academic Year 2021-2022)





CERTIFICATE

ALGAE CULTIVATION

Algae production provides a sustainable source of biomass for bio-based products, feed, fuel and foods, creating high-quality jobs for an educated workforce. This Web-blended program provides that education and combines concepts with hands-on training. The Certificate in Algae Cultivation counts toward the Associate in Applied Science in Controlled Environment Agriculture.

CAREER OPPORTUNITIES INCLUDE
Biological Technician, Engineer, Entrepreneur, Lab Technician, Plant Technician, Project Developer

LEARN MORE
www.sfcc.edu
505-428-1641

SFCC
SANTA FE COMMUNITY COLLEGE

thealgaefoundation.org

SFCC
SANTA FE COMMUNITY COLLEGE

thealgaefoundation

Providing a skilled workforce to meet the needs of the rapidly-growing bioeconomy.

Comprehensive education that combines concepts with hands-on training in our A.A.S. in Controlled Environment Agriculture and embedded Algae Cultivation Certificate.

- Biological Technician
- Plant Technician
- Lab Technician
- Engineer
- Project Developer

ATEC
ALGAE TECHNOLOGY
EDUCATIONAL CONSORTIUM

SFCC
SANTA FE COMMUNITY COLLEGE
CENTER OF EXCELLENCE
BIOFUELS

Algae Cultivation Certificate Courses

- ALTF 161 – Introduction to Algae Cultivation (+ online)
- ALTF 271 – Biology of Algae (+ online)
- ALTF 261 – Advanced Algae Cultivation (+ online)
- ALTF 262 – Algae Harvesting (+ online)
- ALTF 268 – Algae Capstone
- ALTF 298 – Internship
- PLMB 141 – Pumps and Motors (+ online)
- WATR 166 – Microbiology for Water Operators
- BLDG 111 – Construction Safety

LEARNING OUTCOMES AND SKILL SETS

		ALTF 161	ALTF 261	ALTF 262	ALTF 298 / ALTF 268	PLMB 141	BIOL 111	BIOL 111L	WATR 166	ALTF (Phyc)	Bioinfomatics	BLDG 111	Short course
1	Media preparation	x	x					x	x				x
2	Sterile technique	x	x					x	x				x
3	Microscopy	x	x					x	x				x
4	Culture inoculation	x	x					x	x				x
5	Scale up: colony to 10L	x											x
6	Scale up: 10L to >500L		x										x
7	Monitoring procedures for biomass analysis	x	x	x					x				x
8	Lab and farm safety	x	x	x		x			x			x	x
9	Operations and maintenance	x	x	x		x			x				x
10	Harvesting operations			x					x				x
11	Biomass analysis and quality assessment		x	x					x				x
12	Biomass storage techniques		x	x									x
13	Heterotrophic growth and fermentation		x	x					x	x			x
14	Algae identification	x	x	x					x	x			x
15	Pathogen/predator identication	x	x	x					x				x
16	Treated wastewater utilization		x	x					x				x
17	Quality control analysis	x	x	x					x				x
18	Data collection and analysis	x	x	x				x	x				x
19	Internship				x								
20	Pump and motor operations					x			x				
21	Hydraluic sizing					x							
22	Electrical demand requirements					x			x				
23	Mechanical properties of water					x			x				

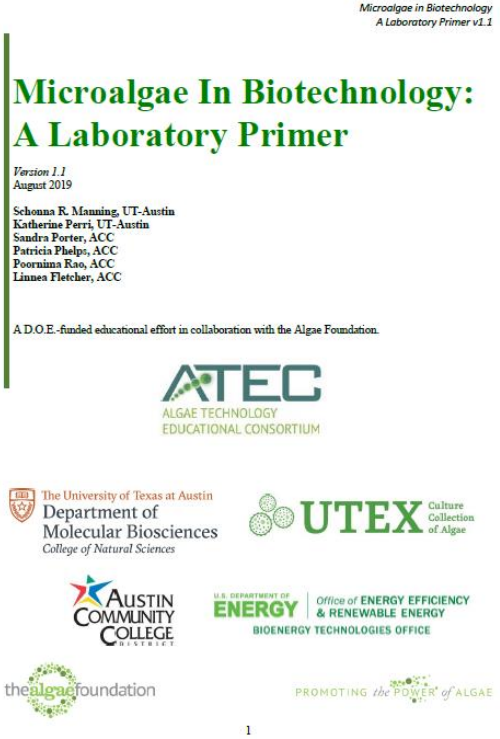
Algae Biotechnology

New Concepts & Pedagogy

- 1500 participating students (cumulative – 4 years, 10 schools)
- Completion of Biotech Lab Primer (Nov 2019)
- Completion of Intensive I and Intensive II lab courses (Sep 2020)
- Completion of **I**mage **G**uided **S**tandard **O**perating **P**rocedures (Jan 2021)

Kalyani Maitra, Ph.D.
Assistant Professor, Department of Chemistry and Biology
California State University, Fresno

"The IGSOPs have been done with great care and detail to not only enhance student understanding but also aid a students'/instructors' preparation of the lab. The experiments in the Primer are very well written and are reproducible to give students a good perception of Algal Chemistry. My students in the research lab have also started employing some of these techniques and have been producing results as good as the techniques that we employed earlier from other journal articles."



Algae Biotechnology Curricular Insertions

- **BITC 2350 Bioinformatics (online)**
  The Analysis of Algal Barcode Sequences lab will use data obtained from BITC 2441 to identify strains to the level of genus, and sometimes species using BLASTn, sequence alignments (CLUSTAL), and phylogenetic analysis

- **BITC 2411 Laboratory Instrumentation**
  The Analysis of Microalgal Lipids lab contains the following modules: lipid extraction, lipid class analysis by TLC, fatty acid derivatization to FAME, and quantitation of FAME using GCMS

- **BITC 2431 Cell Culture Techniques**
  The Microalgal Culture Methods lab includes the following modules: media and vessel preparation, maintaining stock cultures and scaling up, growth kinetics and biomass metrics, i.e., hemocytometry (cells/mL), DW, AFDW, optical density (A680 and A750), and related calibration curves

- **BITC 2441 Molecular Techniques**
  The DNA Barcoding Lab Modules: genomic DNA extraction, PCR, gel verification, product purification, sequencing, and analysis

- **BIO 1415**
  Manufacture of an Algal Product = Algae Balls!

Algae Biotechnology Intensive Lab Courses

Two independent 1-credit labs

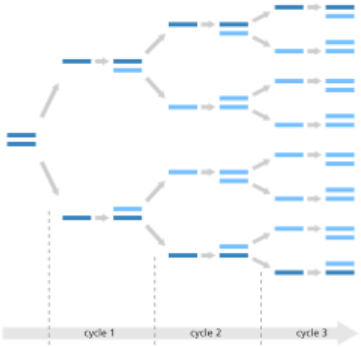
Monday	Tuesday	Wednesday	Thursday	Friday
Culture Maintenance Media preparation, sterile technique, microscopy, and spectrophotometry	Gravimetric Analysis Wet weight, dry weight, ash-free dry weight, % moisture and % solids,	DNA Part I Isolation of DNA and RNA, PCR barcoding, and preparing samples for Sanger sequencing	DNA Part II Gel electrophoresis, sequence analysis, and an introduction to bioinformatics	**Overview of Laboratory Skills - and - Lab Practical**
Genetic Engineering I Plasmid construction, transformation	Genetic Engineering II Plasmid construction, transformation, and screening	Biochemical Analysis I Total lipids, proteins, and carbohydrates, and analysis of lipids by TLC	Biochemical Analysis II Instrumentation and analysis of fatty acids and amino acids by GCMS	**Overview of Laboratory Skills - and - Lab Practical**

Image Guided Standard Operating Procedures (IG SOP's)

Detailed operational planning guides to Laboratory Primer, Lab Intensives 1 and 2

Materials

- Invitrogen Platinum Taq Kit
  - Platinum Taq
  - 10× PCR Buffer
  - $MgCl_2$ (25 mM)
- dNTP mix (10 µM each nucleotide triphosphate)
- Ice bucket with ice
- Sterile water
- Primer stocks for ITS-2 and 23S (4 total, including forward and reverse)
- Sterile 1.5-mL microcentrifuge tubes
- Sterile 200-µL thin-walled PCR tubes and rack
- P10, P20, P200, and P1000 micropipettes and sterile tips
- Microcentrifuge with 1.5-mL and PCR-tube rotors
- Vortex mixer
- Thermal cycler
- Fine-tipped marker
- Purified algal DNA: positive (+) control and unknown/test DNA



Important Notes:

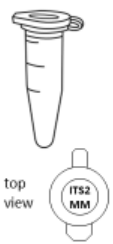
- Work in a designated clean area.
- Do not cross-contaminate ITS-2 and 23S primers.
- Prepare separate Master Mixes for each amplification reaction.
- PCR conditions are different for each primer set so you will need to use two thermal cyclers or perform two separate runs.

2. Prepare ITS2 MM in a labeled 1.5-mL microcentrifuge tube on ice by adding the reagents in the order presented. Mix well by vortex and centrifuge at RT for 5000 rpm, 30 s.

Expert Note: when pipetting Taq, do not submerge the pipette tip below the surface of the reagent – work at the surface to avoid getting excess materials on the outside of the tip.

Reagent Name	Total volume (n+1 samples)
H_2O	235.8 µL
10× Buffer	30.0 µL
$MgCl_2$	9.0 µL
dNTP mix	6.0 µL
ITS-2 F primer	6.0 µL
ITS-2 R primer	6.0 µL
Platinum Taq	1.2 µL

(a) Label Tube ITS2 MM



(b)

Combine reagents in the order listed, adding Taq last

(c) Mix well by vortex

(d) Centrifuge* to pull all of the contents to the bottom of the tube

**balance* the rotor!

ATEC Micro Credentialing Digital Badge Program

ALGAE BIOMASS ORGANIZATION

Endorsed July 22, 2019

- **Digital Badges transform good job candidates into great ones, enhancing marketability of their experience and skill sets**
- Training through digital credential platforms are quickly verifiable, easily shared and build awareness, value and demand for potential bioeconomy job applicants.
- ATEC community college schools embed the badging program into the algal-based courses, providing meaningful training scenarios that students can apply to their collegiate degree programs and to verify developed skills for employment opportunities.

Asynchronous Online Aquaculture Extension Learning Opportunities

Algae Cultivation Extension Short-Courses (ACES)

- Part 1. Seaweeds
  - Published Mar 2019
  - 1,152 Registrations
  - US, India, Indonesia, Australia (57 countries)

Total of 66 countries for Parts 1 & 2

- Part 2. Microalgae
  - Published Aug 2019
  - 687 Registrations
  - US, India, Vietnam, Canada, Indonesia, Mexico (42 countries)

Educational collaborative with national organizations

- InnovATE*BIO*: National center grant based at Austin Community College offers access to the nation's community college biotechnology programs
- National Science Teacher Association (NSTA) provides access to 40,000 science teachers and larger source of Algae Academy enrollees
- Future Farmers of America provides direct access to 8500 chapters and 750,000 students
- USDA –awarded grants in 2020 & 2021 supporting rural, farming, under-represented populations and communities

InnovATE*BIO*
National Biotechnology Education Center

nsta
National Science Teaching Association

USDA

Partnerships with Federal Agencies

USDA

Algae Summer Science Institute: K-12 Teacher professional development and training workshop focused on readying teachers to lead Algae Academy. USDA, National Institute of Food and Agriculture, Total Award $150,000: 2019-68010-29283

Algae in Agriculture Education Alliance: K – 12 outreach effort focused on developing "algae as agriculture" curriculum for FFA chapter schools. USDA, National Institute of Food and Agriculture, SPECA, Total Award $25,000

Kelps for sustainable offshore ocean farming: research, education, and extension. USDA, National Institute of Food and Agriculture-SAS. Total Award $ 10,000,000 (pending) Co-PI. Submitted by USC.

DoD

STEM Education with Algae Series (SEAS): A K-16+ STEM educational program for military connected students, student veterans and active military members. Department of Defense, NDEP Program 1: STEM Activities, Total Award $ 6,000,000 (pending)

Gamification for Algae-based STEM Education (initiated)

- Gamification transforms STEM learning for 21st Century Skills
  - Cognitive, Motivational, Affective, and Sociocultural (Plass, 2015)

Design Discovery Immersion Creativity Engagement Teamwork Interactive

- Modules to be developed
  - Tabletop Game
  - Minecraft Education
  - Role-Playing Game
  - Simulation and Virtual Reality Tour
  - Video Game for popular distribution
  - Introduction to Programming
  - Machine Learning and Data Science

Viticulture by Stonemaier Games (2013)

Plass, J. L., Homer, B. D., & Kinzer, C. K. (2015). Foundations of Game-Based Learning. *Educational Psychologist*, *50*(4), 258–283.

		Tabletop game	Minecraft Edu	Role-playing Game	Simulation	VR Tour	Machine Learning	Intro to Programming
STEM Crosscutting Concepts	Patterns	X	X	X	X	X	X	X
	Cause/effect Mechanism	X	X		X		X	X
	Scale, proportion				X	X	X	
	Systems & models	X	X	X	X		X	X
	Energy & Matter	X	X		X	X	X	X
	Structure & Function	X	X	X	X		X	X
	Stability & Change	X	X	X	X		X	X
STEM Core Disciplines	LS1 Molecules, Organisms	X	X		X		X	
	LS2 Ecosystems, Energy	X	X	X	X	X	X	X
	ESS3 Earth & Human Activity	X	X	X	X	X		
	ETS1 Engineering Design		X		X	X	X	X
	ETS2 Link tech, society	X	X	X	X	X		X
STEM Practices	Questions & Problems	X	X	X	X	X	X	X
	Develop Models		X	X	X	X	X	X
	Plan & Investigate		X	X	X	X	X	X
	Analyze & Interpret	X	X		X	X	X	X
	Math and Computation	X	X	X	X		X	X
	Explain and Design		X	X	X	X	X	X
	Argue Evidence	X		X			X	X
	Evaluate and Communicate	X	X	X	X		X	X

Algae Module in MINECRAFT EDUCATION EDITION

IMMERSIVE STEM LEARNING

CLASSROOM-FRIENDLY FEATURES

CREATIVITY AND INNOVATION

21ST CENTURY SKILLS

A 2017 study of elementary students using Minecraft in school found significant improvements in creativity, collaboration, problem-solving, and computational thinking skills.

98%

of teachers surveyed cited problem-solving as the top skill their students learn from Minecraft.

JOB PREPAREDNESS & STEM

In a study by the Joan Ganz Cooney Center, teachers reported that games like Minecraft led to improvement in computational thinking. This matters when 58% of STEM jobs are in computing, but only 8% of STEM graduates study computer science.

71%

of teachers using digital games reported improvement in student numeracy and computational thinking.

SOCIAL-EMOTIONAL LEARNING

The Microsoft Class of 2030 research revealed that future-ready students will need more than tech skills to succeed. Teachers in 11 countries cited collaboration, decision-making, and communication as top skills cultivated by Minecraft.

40%

of jobs in growth industries require soft skills, those fostered by social and emotional learning (SEL).

A Game for Popular Distribution can be Created Using the Algae Farm Simulation as a Foundation

This tea farming game serves as a model for the algae farming video game.

(Two Leaves and a Bud - Tea Garden Simulator by Flying Robot Games, 2021)

Simulation algae farm

- Students can be engaged through the use of storylines and mission models
  - Build options
  - Control options
  - Mission options
- Real world scenarios allow students to test their understanding and skills in real world situations and see if they can create better outcomes
- Can be used embedded in curriculum or as a stand alone app for student or adult use.

ATEC Prepares People to Get Bioeconomy Jobs

Management

- 700+ schools/ 40+ staff, consultants, and volunteers/ 6 major endeavors
- Horizontal management philosophy
- Dedicated to DE&I and economically disadvantaged schools and districts
- Identify and mitigate risks/challenges
- Curriculum relevance maintained through IAB

Approach

- State-of-the-art curriculum development and innovative future algae topics
- COVID-19 pivot to online education
- Dissemination via BETO workforce development web platform, publications, presentations and social media
- Curriculum translation into spanish & several indigenous languages
- Elimination of economic barriers to program adoption

Impact

- **>100,000 total ATEC participants to date**
  - ~150 Farming college students
  - ~1,500 Biotechnology college students
  - ~20,000 Algal MOOC participants (> 10 countries)
  - ~1,850 ACES trainees (66 countries)
  - ~80,000 Algae Academy students

Future Progress and Outcomes

- Development of equipment sharing program
- Dedicated DE&I officer and extended outreach
- Microcredentialing badging program
- National grant applications & fundraising
- National Organization with access to:
  - NSTA – 40,000 Science Teachers
  - FFA – 750,000 Farming Students
  - InnovATE*BIO* – > 100 biotechnology degree granting community colleges

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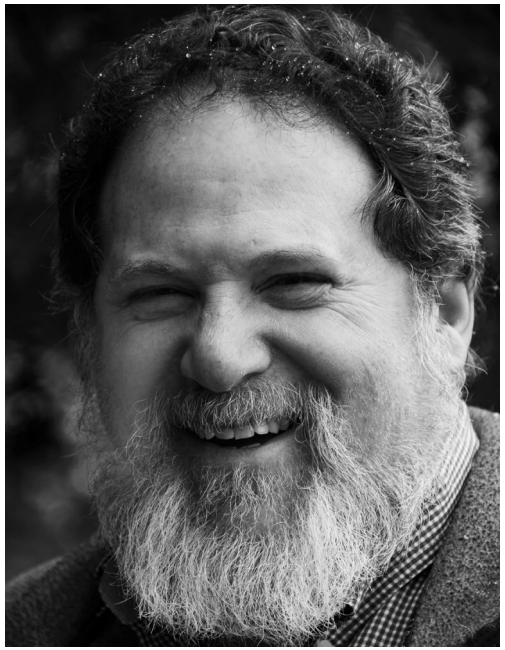
Thank you!



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