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BIOENGINEERING AS ART

(SANAT OLARAK BİYOMÜHENDİSLİK)

Zalike KESKİN[1], E.Esin HAMEŞ[2], Aylin ŞENDEMİR ÜRKMEZ[3]

ABSTRACT

Bioengineering is a rapidly growing area that is commonly defined as a highly multidisciplinary engineering field. The organising committee of the 7. International Bioengineering Congress decided to add a different and innovative perspective to our understanding of the multidisciplinary nature of bioengineering. “Bioengineering As Art” contest is one of the three exhibitions of the congress Bec2015, was conducted with the theme of *“biodesign - solutions of nature for societal challenges”*, has attracted much interest from participants and delegates and also presented in that paper.

Keywords: Naturally colored cotton, Textile industry, Plant biotechnology, Synthetic chemical dyes

ÖZ

Biyomühendislik alanı multidisipliner mühendislik alanlarının birlikteliğinin yanı sıra hızla büyüyen bir alandır. 7. Biyomühendislik Kongresi organizasyon komitesi doğası gereği interdisipliner bir yapısı olan biyomühendisliğefarklı ve yenilikçi bir bakışı hedefledi. Sanat olarak biyomühendislik sergisi, "Biyotasarım- Toplumsal Avantaj için Doğanın Çözümleri" başlığı ile düzenlenen Bec 2015'in üç sergisinden biri olup bu yazıda farklı katılımcıların açılımları sunulmaktadır.

Anahtar Kelimeler: *Doğal renkli pamuk, Tekstil endüstrisi, Bitki biyoteknolojisi, Sentetik kimyasal boyalar*

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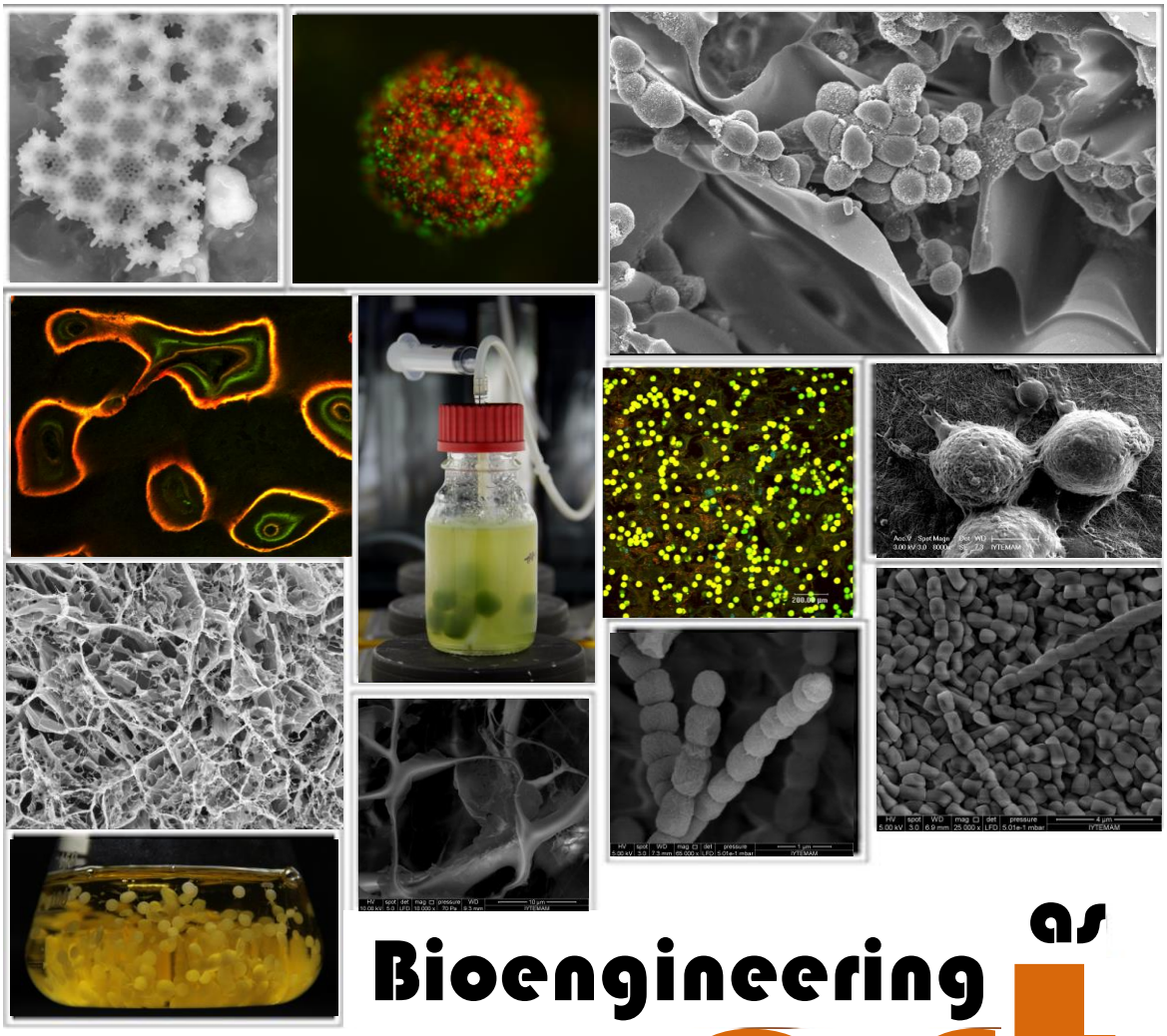


Figure 1. Poster of the exhibition of "Bioengineering As Art"

Bioengineering is a rapidly growing area that is commonly defined as a highly multidisciplinary engineering field. The Organising Committee of the 7. International Bioengineering Congress decided to add a different and innovative perspective to our understanding of the multidisciplinary nature of bioengineering. BEC2015 was conducted with the theme of ***"Biodesign - solutions of nature for societal challenges"***, which is a timely introduction to the emerging concept of integrating design and manufacturing with biology, creating a new means of communication and exploration, provoking debate, and excavating unforeseen opportunities of bioengineering. "Bioengineering as Art" contest is one of the three exhibitions of the Congress, and has attracted much interest from participants and delegates.

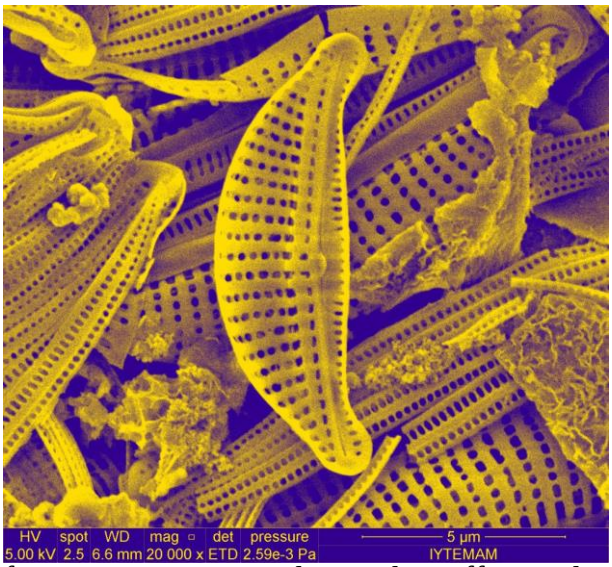
Art and Science, more alike than different, when we rethink about the meaning of creativity and open-mindedness, the driving forces of both artists and scienctist. The exhibition of "Bioengineering as Art" contest was aimed to prove the interconnection of bioengineering and art with aesthetic, as well as imaginative images from different scientific research. This letter includes some of these images and their summarized descriptions.

"Art is the queen of all sciences communicating knowledge to all the generations of the world"

(Leonardo da Vinci)

Amphora

Meltem Conk Dalay (Ege University, Engineering Faculty, Bioengineering Department, Izmir)



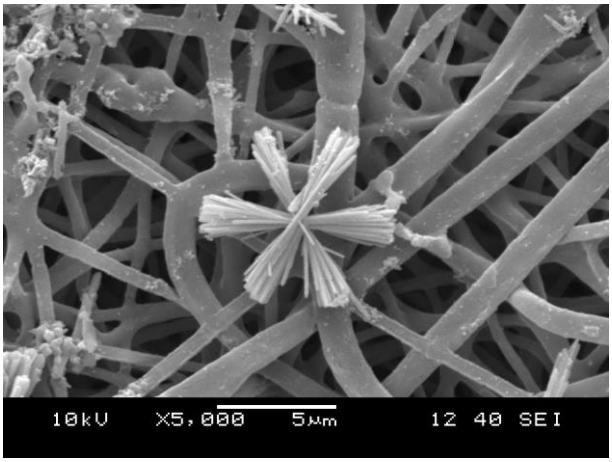
Amphora is a major genus of marine and fresh water diatoms. With over 1000 species, it is one of the largest genera of diatoms. Regarding to their shape, Amphora genus members take thair name from their similar shape to "amphora" used for storage and transport of olive oil and wine in Ancient Greece and Romans.

Diatoms preserved in the EGEMACC (Ege University Microalgae Culture Collection http://egemacc.com/) are usually maintained by serial sub-culturing. The cryopreservation of marine diatom algae (*Amphora cf. capitellata*, *Cylindrotheca closterium*, *Nanofrustulum shiloi*) using the passive freezing system procedure and its effect on lipid productivity was investigated in this study*. *This image and its owner were awarded the best shot taken at the Bioengineering as Art contest.*

*"Non-cryopreserved and Cryopreserved Diatoms Cultuvation and its effect on Lipid productivity". 7th International Conference "Biosystems Engineering 2016" May 12-13, 2016 in Tartu, Estonia.

Crystals Like a Flower

İrem Ünalan(Department of Biomedical Technologies, Dokuz Eylul University, Izmir)
Cansu Görgün (Department of Biomedical Technologies, Ege University, Izmir)



Tissue engineering is a developing interdisciplinary field that applies the principles of engineering, medicine and life sciences to the restore, maintain, or improve tissue function. Scaffold plays an important role in tissue regeneration and repair. It is important for the scaffold to mimic the fibrous form of the natural extracellular matrix (ECM). Also, surface properties such as hydrophilicity and surface charge are important in defining cell behavior. Most polymeric materials are hydrophobic in nature, and their surfaces are not suitable for polymer–cell interactions. Plasma surface modification technique is proposed to modify the hydrophobic surfaces of polymers. The objective of this study is to produce biocompatible and biodegradable poly(3-hydroxybutyrate-co-3-hydroxyvalerate) (PHBV) nanofiber mats by electrospinning for bone tissue engineering. In order to increase the surface hydrophilicity, radio-frequency (RF) plasma treatment using oxygen (O_2) gas was applied. Then, silk fibroin (SF) was immobilized on the mats to improve the biocompatibility. *In vitro* biological evaluation of the O_2 plasma-treated silk fibroin modified PHBV nanofiber mats was investigated using human osteoblast-like SaOS-2 cell line. These crystals are probably due to sucrose used during cell fixation procedure for SEM analysis.

This image and its owners were awarded for the second best shot taken at the Bioengineering as Art contest

Rebellion with Micro Filaments in the Ocean

İrem Deniz (Ege University, Engineering Faculty, Bioengineering Department, Izmir)

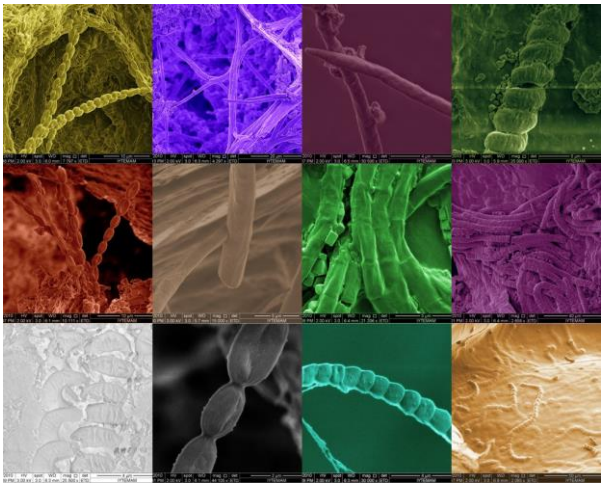
"Rebellion with micro filaments in the ocean" entitled image is a SEM imaging of *Chrysoreinhardia sp*. isolated from ocean.

The photo was taken in order to enhance microalgal strain database of Ege University Microalgal Culture Collection (EGEMACC). The firstly reported *Chrysoreinhardia* strain was collected in 1979 from the rhizomes of a macroalgae under the water. Chrysoreinhardia sp. is a member of Pelagophyceae class. The development of Chrysoreinhardia sp. is generally maximal at the end of spring and in summer. The microalgae is acting like standing up to confront the world and showing a rebellion in the ocean with its tiny filaments of 0.05 µm.

This image and its owner were awarded for the second best shot taken at the "Bioengineering as Art" contest.

Cyanobacteria

Zeliha Demirel (Ege University, Engineering Faculty, Bioengineering Department, Izmir)



This study was investigated the presence of cyanobacteria in 5 different hot springs (Balcova, Zeytindali, Karakoc, Sifne and Gulbahce) in Izmir. Ten cyanobacterial cultures was isolated and cultivated, *Spirulina subsalsa, Geitlerinema, Leptolyngbya, Lyngbya, Oscillatoria, Pseudoscillatoria, Phormidium* sp..16S rDNA sequences from 10 filamentous cyanobacteria were obtained and phylogenetic tree from these sequences. Cyanobacteria algae grow in the freshwater and marine. Because they are bacteria, they are quite small and usually unicellular, though they often grow in colonies large enough to see. The cyanobacteria are still around; they are one of the largest and most important groups of bacteria on earth.

Dancing of Daffodils and Sisterhood of Narcissus Bulblets *In vitro*

Meltem Bayraktar (Ahi Evran University, Faculty of Engineering and Architecture, Genetic and Bioengineering Department, Kirsehir/Turkey)
Canan Yılan (Ege University, Faculty of Engineering, Bioengineering Department, Bornova-Izmir/Turkey)
Aynur Gürel (Ege University, Faculty of Engineering, Bioengineering Department, Bornova-Izmir/Turkey)

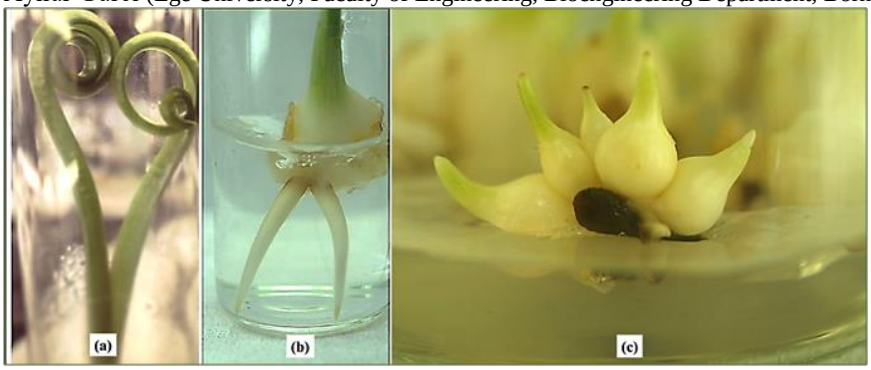


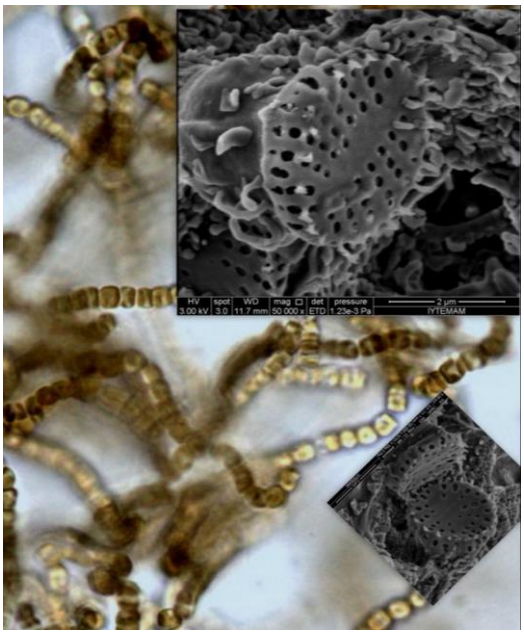
Figure: Daffodils were developed *in vitro* conditions: a: Heart shaped leaves; b: Ballerina legs shaped roots; c: Sisterhood of narcissus bulblets

The genus *Narcissus* (daffodils), belonging to the Amaryllidaceae family, is grown Western Europe, Mediterranean Region, China and Japan. In Turkey, it spreads over especially Karaburun and Mordoğan. *Narcissus tazetta* ssp. *Tazetta* is a bulbous plant and has a great potential as an ornamental plant due to its attractive flowers and fragrance. There are several limitations to production of *Narcissus*: The vegetative propagation rate under field conditions is very slow, plant material used for the conventional propagation by twin-scaling and chipping is soil borne and is affected negatively from diseases which can be transferred from one generation to the next, the bulbs are degenerate with age because of asexual reproduction. Consequently, *in vitro* clonal propagation presents a good alternative for the commercial production of daffodils. The purpose of this study was to describe an efficient and economic micropropagation method for *N. tazetta* ssp. *tazetta*. Initially, to develop a sterilization protocol, the bulbs of *N. tazetta* ssp. *Tazetta* were exposed to different sterilization procedures and they were longitudinally sectioned to give 5 mm x 5 mm twin-scales explants joined by 2mm of plate from the internal scales. The twin-scales explants were cultured on a special

plant tissue culture medium containing different plant growth regulators for the shoot regeneration and proliferation. After the determination of shoot proliferation medium, the shoots regenerated were then subcultured continuously on this medium for the further studies. Some of the *in vitro* shoots were cultured for the *in vitro* bulblet formation and the rest of shoots were used for *in vitro* rooting. During this study, we encountered some visual beauties depending on the plant growth regulators and nutrient medium composition. The figure presents essentially three different organs of daffodils grown *in vitro*: (a) leaf, (b) root, (c) bulblet. However we imagined them in different ways and renamed as heart shaped leaves (a), ballerina legs shaped roots (b) and sisterhood of narcissus bulblets.

Nanofrustulum shiloi

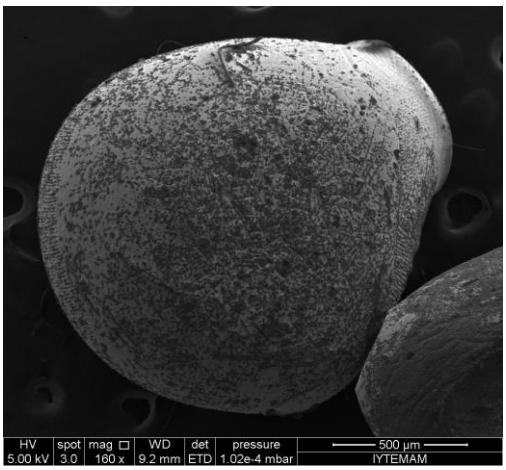
Esra Imamoglu (Ege University, Engineering Faculty, Bioengineering Department, Izmir)



Nanofrustulum shiloi was studied for the European Community's Seventh Framework Programme (FP7/2010-2014) under grant agreement number 245137 (FP7-KBBE-2009-3) with the project title of "Exploring Marine Resources for Bioactive Compounds: From Discovery to Sustainable Production and Industrial Applications (MAREX)". *Nanofrustulum shiloi* was collected and isolated from Sıgacik-Mavi Teos Aegean Sea with the location coordinates of 38º10´59.79´´ N, 26º46´18.59´´ E in Turkey. The sample was taken on June 2011 in the superficial layer of the water column with 20 µm plankton net. The clonal culture was isolated in September 2011 under the water temperature of 22.8°C with the salinity of 36 psu. The isolation of the strain was done using serial dilution and the streaking plate method. The isolated strains were examined for morphological features by using both fluorescent microscope and scanning electron microscope (SEM) images. For light microscopy observations, cells were examined with a Leica DMIL fluorescent microscope (Leica, Germany) with 63 X achromatic objective lens. For SEM sample preparation, a few drops of cultured medium were dried on a glass and washed with distilled water without staining. The samples were examined by using FEI Quanta-250 FEG scanning electron microscope (FEI Company, Czech Republic). The isolated & identified strain of *Nanofrustulum shiloi* was joined to Ege University Microalgae Culture Collection (EGE MACC) and coded with EgeMacc-047. Diatom cells are in short chains, linked by interlocking marginal spines. Valves are circular to slightly oval 2-6 µm diameter. The valve face was flat and with small granules around the spines. Frustules are rectangular, forming chains linked by interlocking marginal spines.

Landed punch to microorganisms

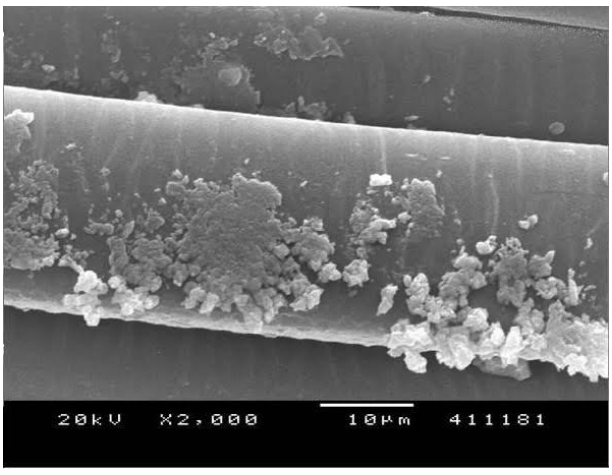
Emine Erdoğan Özşeker (Ege University, Science and Literature Faculty, Biochemistry Department)
Alper Akkaya (Ege University, Science and Literature Faculty, Biochemistry Department)



In recent years, increasing risk of infection, caused by resistant microorganism to antibiotics, has become the limelight discovery of new and natural antibacterial materials. Heavy metals, such as silver, zinc, copper, mercury and titanium, have antibacterial activity. Products, improved these metals, do not have stable antibacterial property. Therefore, use of these products is restricted. The aim of this study was to immobilize of tetracycline to alginate and improve an antibacterial biomaterial. For this purpose, calcium-alginate beads were formed by dropping to calcium-chloride solution and tetracycline was immobilized to beads using 1-Ethyl-3-(3-dimethylaminopropyl) carbodiimide (EDC) at optimum conditions. This image was obtained by SEM and this is a tetracycline immobilized calcium alginate bead. Improved product has potential for open wound, surgical drapes, bed and pillow sheath in hospitals and it may also be used for increasing human comfort in daily life. Complication may be occurred between calcium, presented in alginate, and some chemical such as ethylenediaminetetraacetic acid (EDTA) and citrate. Thereby obtained product can be converted to gel form. After the gel form was obtained, it can be applied some materials and thereby a composite material, can be used for many purposes such as decreasing bleeding time and accelerating wound healing, can be developed.

Secret micro world of fabrics

Alper Akkaya (Ege University, Science and Literature Faculty, Biochemistry Department)

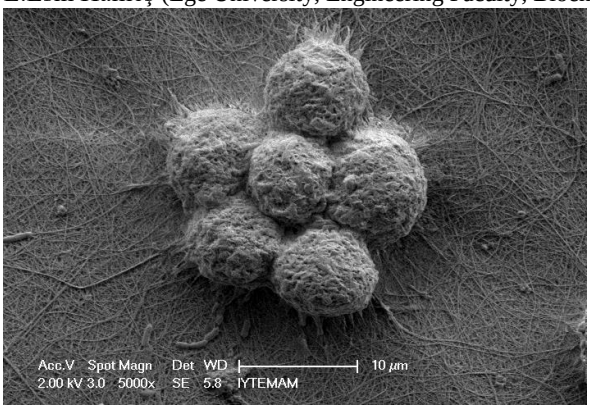


Synthetic fibers form an important part of the textile industry. They have high crystallinity and low moisture regain. They exhibit excellent physical properties of strength, flexibility, toughness, stiffness, wear and abrasion resistance. Beside these properties, they also demonstrate a good dyeing ability, low friction coefficient and good chemical resistance. However, the poor wettability and hydrophilicity make them difficult to apply to finishing compounds, colouring agents, and coupled with flame retardants or covalently immobilize proteins or enzymes. Modifications must be made and functional groups should be added or formed to make them functional or improve properties. Modification of polymers has received much attention recently. Among the methods of chemical polymer modification grafting represents one of the most promising approaches since graft copolymerization will impart a variety of new functional groups to a polymer. Polypropylene (PP) fabric is one of the most produced synthetic fabric in the world. Its production and usage increase at medical textile. There is no functional group in its structure for biomolecule immobilization. Hence, it is not inclined to

react. However, functional groups could be added to their structure using graft polymerization. In this study, methacrylic acid was graft-polymerized to poly(ethylene terephthalate) and poly(acylonitrile) fabrics.

Freshly Baked Flower Bread Cells

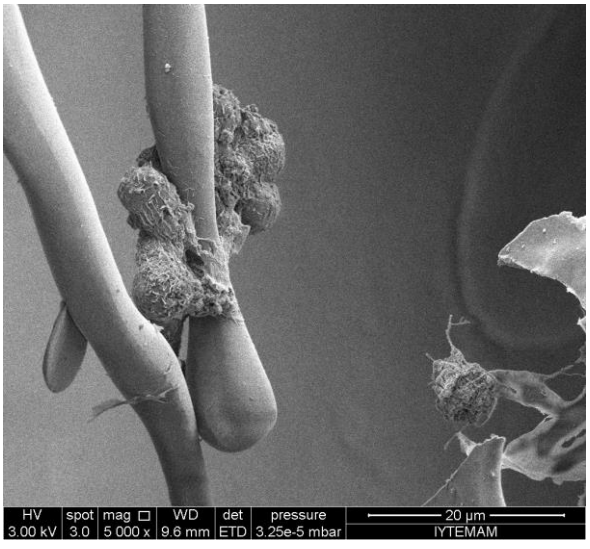
Zalike Keskin(Ege University, Engineering Faculty, Bioengineering Department, Izmir)
Aylin Sendemir Ürkmez (Ege University, Engineering Faculty, Bioengineering Department, Izmir)
E.Esin Hameş (Ege University, Engineering Faculty, Bioengineering Department, Izmir)



Bacterial cellulose (BC), and keratin are both qualified materials that have potentials in tissue engineering and various biomedical applications. BC, is a natural polymer which has good mechanical properties, fiber network structure, biocompatibility etc. Additionally Keratin, has high biodegradability, biocompatibility and also provides adhesion of keratinocytes. Pursuant to this part of relevant study *in vitro* cell culture experiments have been investigated with human skin keratinocytes and human skin fibroblasts for indicate potentials of the BC composite on skin tissue engineering. This study also has potential to create a comprehensive basis for other prospective studies containing *in vivo* experiments and developing the modified BC-based artificial skin. In the image HS2 (human skin keratinocytes) cells attach on bacterial cellulose nanofibrils. They come together and seems like a flower bread, in details on the image we can say some bacteria will come to eat it.

My dear chitosan

Müge Anıl (Ege University, Engineering Faculty, Bioengineering Deparment)



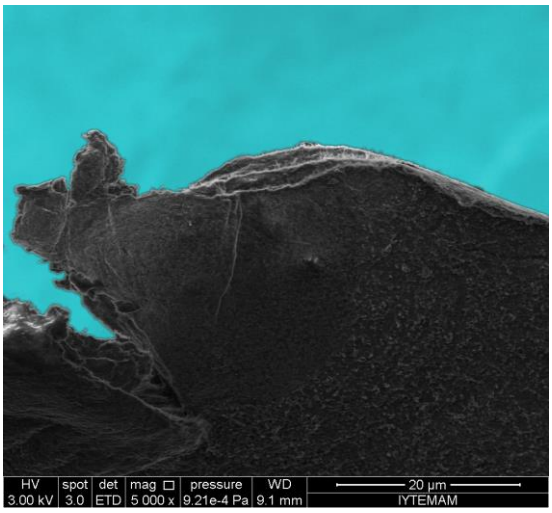
The image represents an osteosarcoma cell group hugging the chitosan scaffold like a koala to survive under various death-inducing conditions.

Traditional two-dimensional (2D) cell culture system, a convenient way to study cancer *cells in vitro,* is not successful to mimic the tumor structures plays key role in cancer tissue. The three-dimensional (3D) cell culture system *in vitro* is closely related to tumorigenicity *in vivo.* Cancer stem cell (CSC) population is a small subset of cells within a tumor with high tumoregenicity and metastase potential. The aim of this study was developing a 3D osteosarcoma model and investigation features of this subpopulation in this model.In this study, osteosarcoma stem cells (OSCs) were isolated from an osteosarcoma cell line by magnetic-activated cell sorting technique. The porous chitosan scaffolds were prepared by freeze-drying method. To observe cell morphologies, cultured OSCs in the scaffold were examined by scanning electron microscopy (SEM). The SEM image represents an osteosarcoma cell group attached to the chitosan scaffold. This chitosan scaffold based 3D cancer model mimics *in-vivo* tumor conditions and

can be used to study CSC behaviour and tumourigenesis *in vitro*.

Microfish

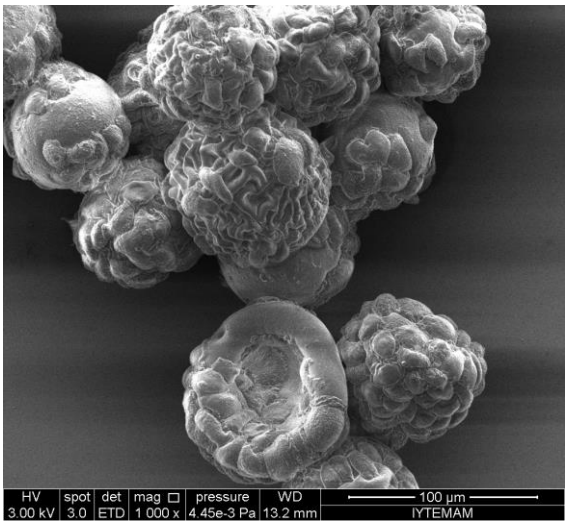
Aysegul Inam (Ege University, Engineering Faculty, Bioengineering Department
Ramazan Maden(Ege University, Engineering Faculty, Bioengineering Department
Zalike Keskin(Ege University, Engineering Faculty, Bioengineering Department
Esin Hames(Ege University, Engineering Faculty, Bioengineering Department



Cellulose is the most common biological macromolecule on the earth and it is also can be sythesized some bacteria which called bacterial cellulose (BC) it is a natural biopolymer that has properties of biocompatibility, high mechanic strength and water absorbtion capability, pure chemical nanoporouse structure. Thanks to its these excellent properties clinical success of BC has been proved in tissue engineering, medicine, cosmetic, veterinary. In recent years biomedical applications of BC is ever increasing. This study was aimed production and celulase modification of BC based vugular medical mesh. BC, which could be produced desired shape and size has most of propertirs that must required for mesh such as biocompatibility, elasticity, strength,
This image was obtained from cross-section area bacterial cellulose. Mineralized salts on the BC, sourced from degredation studies that performed with simulated body fluid (SBF) buffer look like fish scale on micro size.

Dance of The Cells and Microcarriers

Pelin Saglam Metiner (Ege University, Faculty of Engineering, Department of Bioengineering, Bornova/Izmir, 35100, Turkey)
Sultan Gulce-Iz (Ege University, Faculty of Engineering, Department of Bioengineering, Bornova/Izmir, 35100, Turkey)
Mert Doskaya (Ege University Faculty of Medicine, Department of Parasitology, Bornova/Izmir, 35100, Turkey)



T. gondii tachyzoites which are produced in susceptible animals, are used as source of antigens for the serological diagnosis of toxoplasmosis infection. However, the quantity of the yield is almost always limited. The aim of this study is to increase the scale production of *T. gondii* tachyzoites to be used as antigen in immobilized HeLa cell spinner flask cultures.
Tachyzoites were inoculated to HeLa cells on Cytodex 1® microcarriers in the 50 ml spinner flasks at 37°C. Three different culture media, compositions, two initial cell concentrations and two different cell/tachyzoite inoculation ratios as well as two bioreactor types and the passage level of the parasites were studied comparatively. Then, the quality of the antigens was evaluated with blood samples of patients with toxoplasmosis using IFAT, ELISA and Western blotting. The produced tachyzoites are intended to be used as a source for drug development, diagnostic kits and vaccination strategies for toxoplasmosis. Also, the use of tachyzoites which were produced by *in vitro* cell

culture techniques will reduce the usage of animals and hence will solve the ethical and economic problems. To our knowledge, this study will be the first research for large scale *T. gondii* tachyzoites production with HeLa cells on Cytodex 1® microcarriers in the spinner flasks.

CV/ÖZGEÇMİŞ

Zalike Keskin; Research Assistant (Araş Gör.)

She has graduated at Ege University Bioengineering Department (2013), also get Master of Science degree from Graduated School of Natural and Applied Science, Department of Bioengineering (2015), as of 2015 September she is pursuing to her Ph.D. at same department. Since April of 2016 she has been working as research assistant at Izmir University of Economics department of Biomedical Engineering. Her research interests are mainly; use of microbial polymers as biomaterials, Biocompatibility and characterization analyses of biomaterials, nanocomposites and animal cell culture studies and tissue engineering applications. She has 5 international and 1 national conference papers.

Lisans derecesini Ege Üniversitesi Biyomühendislik Bölümünde (2013), Yüksek Lisans derecesini Ege Üniversitesi BiyomühendislikAnabilim Dalında (2015) tamamlamış olup, Eylül 2015 itibari ile aynı bölümde doktorasına devam etmektedir. 2016 yılının Nisan ayından itibaren İzmir Ekonomi Üniversitesi Biyomedikal Mühendisliği bölümünde araştırma görevlisi olarak çalışmaktadır. İlgi alanları arasında Mikrobiyal polimerlerin Biyomalzeme olarak kullanımları, biyouyumluluk ve karakterizasyon analizleri, hayvan hücre kültürü çalışmaları ve doku mühendisliği uygulamaları yer almaktadır. 5 uluslararası 1 ulusal bildirisi bulunmaktadır.

Aylin Şendemir Ürkmez; Asst. Prof. (Yrd. Doç. Dr.)
She has received her B.S. degree at Mechanical Engineering (1994), M.Sc. degree at Biomedical Engineering (1997) from Bogazici University, Turkey, and PhD. degree at Materials Science and Engineering (2006) from University of Illinois at Urbana-Champaign, USA. She has been working as an assistant professor at Ege University Faculty of Engineering, Bioengineering Department since January 2009 and currently the principal investigator at Ege Research Group of Animal Cell Culture and Tissue Engineering (EgeREACT). Her research interests include interactions of animal cells and biomaterials, tissue engineering, mechano-transduction, stem cells, cancer stem cells and biocompatibility testing. She is also interested in design and production of novel in vitro disease models in order to minimize animal testing. She has co-authored more than 20 scientific papers, 2 patents and 3 book chapters. Assist. Prof.Dr.AylinŞendemirÜrkmez is a member of the Editorial Board of Challenges in Regenerative Medicine.

Lisans derecesini Boğaziçi Üniversitesi Makine Mühendisliği (1994), Yüksek Lisans derecesini ise, Boğaziçi Üniversitesi, Biyomedikal Mühendisliği (1997) bölümlerinden almış olup, doktorasını Illinois at Urbana-Champaign Üniversitesi, Malzeme Bilimi ve Mühendisliği (2006) bölümünde tamamlamıştır. 2009 yılının Ocak ayından itibaren, E.Ü., Mühendislik Fakültesi, Biyomühendislik Bölümü'nde Yrd. Doç. Dr. unvanıyla çalışmakta olup, Hayvan Hücre Kültürü ve Doku Mühendisliği Araştırma Grubu (EgeREACT)'ın yürütücülüğünü üstlenmektedir. İlgi alanları arasında, hayvan hücreleri ile biyomalzemelerin etkileşimleri, doku mühendisliği, mekano-transdüksiyon, kök hücreler, kanser kök hücreleri ve biyouyumluluk testleri yer almaktadır. Ayrıca, hayvan denemelerinin minimize edilmesi amacıyla, in vitro hastalık modellerinin dizayn ve üretimiyle ilgilenmektedir. 20'den fazla bilimsel makale, 2 patent ve 3 kitap bölümünün eş yazarlığına sahip olmakla birlikte, Yenileyici Tıp'taki Zorluklar (Challenges in RegenerativeMedicine) adlı derginin editörlüğünü yapmaktadır.

E. Esin Hameş; Proffessor (Prof. Dr.)
She has received her B.S. Degree (1992) and PhD. degree (2004) at Basic and Industrial Microbiology from Ege University, Turkey. She has worked as a specialist at Ege University Science and Technology Center (EBİLTEM) between the years of 2004-2009. She has worked as an associate professor at Ege University Faculty of Engineering Department of Bioengineering between the years of 2009-2015. Since September 2015 she has been working as a professor at same department and currently she is the vice department head and principal investigator of Industrial Microbiology Laboratory. Her research interests are mainly based on microbial enzymes, microbial polymers and secondary metabolites. She has co-authored 31 scientific article, 63 conference paper 2 patents pending, 1 book and 2 book chapters.

Lisans derecesini (1992) Ege Üniversitesi Fen Fakültesi Biyoloji bölümünden almış olup, 2004 yılında aynı üniversitede temel ve endüstriyel mikrobiyoloji bilim dalında doktora derecesini tamamlamıştır. Prof. Hameş, 1996-2009 yılları arasında Ege Üniversitesi Bilim ve Teknoloji Merkezinde (EBİLTEM) uzman olarak görev yapmıştır. 2009-2015 yılları arasında E.Ü. Mühendislik Fakültesi Biyomühendislik bölümünde Doç. Dr. unvanı ile çalışmış ve 2015 Eylül ayı itibari ile aynı bölümde Prof. olarak çalışmaya devam etmektedir. E.Ü. Biyomühendislik Bölüm başkan yardımcılığı idari görevinin yanında, Endüstriyel Mikrobiyoloji Laboratuvarının yürütücüsüdür. İlgi alanları arasında mikrobiyal enzimler, mikrobiyal polimerler ve sekonder metabolitler yer almaktadır. 31 bilimsel makale, 63 bildiri, 2 bekleyen patent, 1 kitap ve 2 kitap bölümü yazarlığına sahiptir.