SIMB News

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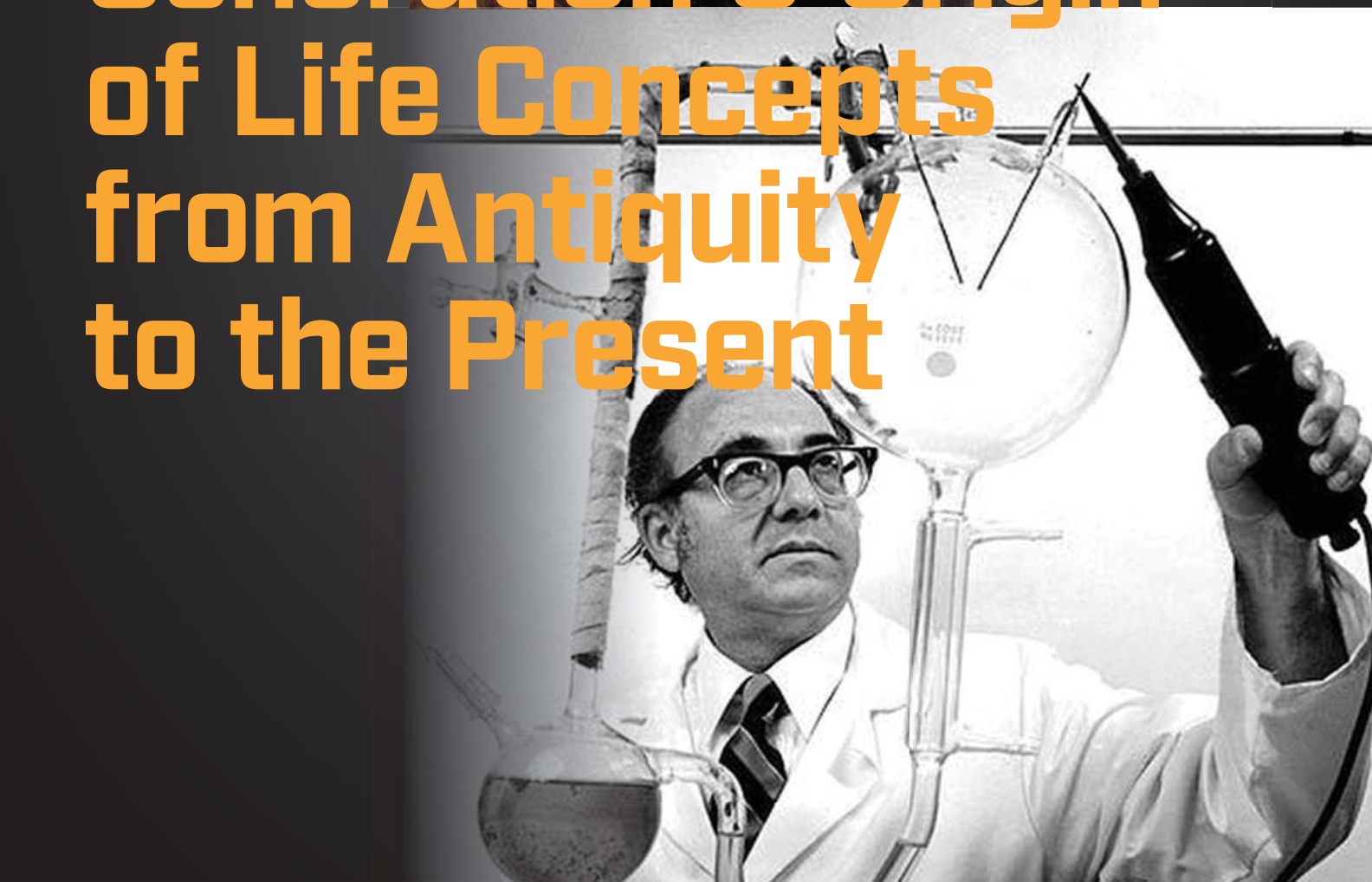
Spontaneous Generation & Origin of Life Concepts from Antiquity to the Present



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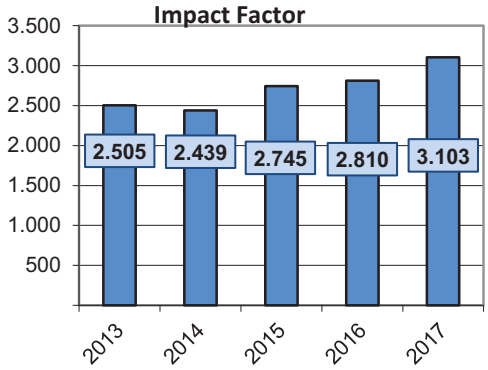

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The Journal of Industrial Microbiology and Biotechnology is an international journal which publishes papers in metabolic engineering & synthetic biology; biocatalysis; fermentation & cell culture; natural products discovery & biosynthesis; bioenergy/biofuels/biochemicals; environmental microbiology; biotechnology methods; applied genomics & systems biotechnology; and food biotechnology & probiotics

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Fermentation: Solving 21st Century Problems

TIM DAVIES, RUBUS SCIENTIFIC LTD.
RAFT® 2019 CO-CHAIR

Biological advances are regularly in the headlines. Seven of the top ten best selling drugs are biologics. CRISPR is almost a household word as is synthetic biology. Biotechnology-derived foods are established in stores and restaurants. New biologically derived polymers are newsworthy, whether they come from spider silk and provide new functionality, or are used for packaging and provide better degradability. Biotechnology has emerged from the biofuel boom with greater diversity and investors are recognising the promise with large investments in companies such as Gingko, Impossible Foods and Indigo Agriculture. Despite this interest, we hear less about biomanufacturing. Manufacturing is the engine that drives the industry – sales revenue is not generated until a product hits the shelves – but it's secrets remain hidden.

Our generation faces huge global challenges, captured in the UN sustainable development goals (Figure 1). Most of these can be impacted by the bio-economy, and by manufacturing products that provide better sustainability and better health. Our industry has the opportunity to be a leader in advancing the sustainability goals but this will need joined up thinking and technological advances. Ultimately it will require increased capacity so that those companies and scientists developing solutions can test, scale and manufacture their products quickly, with reduced risk, and at lower cost. This will facilitate getting the outputs of the bio-economy on to the market where they can displace incumbent products and generate an impact.

The RAFT® conference series has been at the forefront of fermentation and biomanufacturing research and development for almost 30 years and in 2019 the impact of the conference may never have been greater. 300 industry experts will gather under the Florida sun this October to share advances and brainstorm solutions to problems in a vibrant format that encourages discussion. Lecture sessions focussing on the latest research and commercial offerings will be enhanced by round tables addressing some of the critical issues that the industry faces. Most of all we will celebrate the industry. We want to send our delegates home knowing that what they are doing matters, and ready to make a difference.

So, a call to arms: mark your calendars for October 27th to the 30th, get involved by writing poster and paper abstracts so that we can all benefit from your expertise, and come ready to participate and make a difference. We want you at RAFT® 13 this fall.

Figure 1 The UN Sustainablilty Goals - a call to arms for the biomanufacturing industry (*www.un.org/sustainabledevelopment/sustainable-development-goals*)

SIMB-related News

Winners of SIMB science fair awards

Deb Graves, Dow, again judged the Montgomery County, PA Science Research Competition held March 22, 2019. Winners received SIMB-sponsored Amazon gift cards.

Congratulations to all of the schools with winning students:

- Upper Dublin High School
- Cheltenham High School
- Methacton High School
- Germantown Academy Upper School
- St. Teresa of Calcutta School
- Cedarbrook Middle School
- Arcola Intermediate School

SIMB-related News

K. ***Thomas Klasson, PhD, Research Leader, Commodity Utilization Research***

Science Fair 2019 – New Orleans

SIMB sponsored two awards at the 2019 Greater New Orleans Science and Engineering Fair (GNOSEF) for the first time. We anticipate making this an annual sponsorship. This year's Fair was held at Tulane University in New Orleans on February 18-21, 2019. Participation in GNOSEF encourages: independent student research in science and engineering; promotes the understanding and appreciation of sciences; encourages youth to pursue science, math, or engineering careers; stimulate interest and support for science and math programs in area schools; promote collaboration and interaction between area students and scientists and engineers from the community and/or the world. Overall, there were more than 175 entries at the Fair. SIMB sponsored a 1st place award of a Certificate and a $75 gift card for the Junior Division and a $125 gift card for the Senior Division to an individual student who demonstrate the best microbiology- or biotechnology-related project. SIMB Director K. Thomas Klasson served as judge and reviewed entries and spoke with those young scientists who had projects best fitting our criteria. A student from John Curtis Christian School in River Ridge, Louisiana, was recognized with the SIMB Award in the Junior Division for his work investigating which type of cleaning solutions worked best to control *Escherichia coli*. By using a harmless strain, the student added paper disks soaked in cleaning solutions to petri dishes with E. coli and measured the kill zone diameter. The student found that the most effective solution was an antibacterial hand soap, beating out other contenders, including a solution used in hospital-grade wipes. A student representing the Patrick F. Taylor Science & Technology Academy in Westwego, Louisiana, received the SIMB Award in the Senior Division for his work on improving hydrogen production by an algal species. The student refined his previous research, entered in the 2018 GNOSEF, with the algae, *Chlamydomonas reinhardii*. For this year's Fair, he expanded his focus by including data gathered with *C. moewusii*. In photosynthetic bioreactors (transparent plastic tubes), he found that *C. moewusii* produced 270% more hydrogen than *C. reinhardii*, especially when the medium was modified to include higher level of some minerals (e.g., magnesium). He tested three different media to come to this conclusion. Both of these aspiring researchers were well-deserving of the SIMB Award and have a great future in the field of science. SIMB congratulate them and wishes them all the best.

Spontaneous Generation and Origin of Life Concepts from Antiquity to the Present

Erick J. Vandamme

1. SPONTANEOUS GENERATION (SG) VERSUS NEO-DARWINISM

Figure 1: Thomas Henry Huxley (1825-1895), English biologist.

Spontaneous generation (SG) or "generatio spontanea" refers to the direct and quick formation of living cells or organisms from inanimate matter or without descent from similar organisms. Spontaneous generation claimed that different types of life might repeatedly emerge in a time scale of hours, weeks, or a few years from sources other than plant seeds, eggs, or parents, such as river mud, dirt, sand, winds, water, sea foam, and flour (Brack, 1998; Ball, 2016). Although the term SG has been around for centuries, the English physiologist Henry Charlton Bastian (1837-1915) disliked the ambiguity of the name SG and initially referred to it as "archebiosis" for life originating from inorganic matter. However, in 1870 he coined the term "biogenesis" for formation of life from nonliving matter (Bastian, 1871). Since 1859 another term "heterogenesis" was also used by the French naturalist Félix Archimède Pouchet (1800-1872) for the generation of living things from unrelated organisms or from once living organic matter (Farley and Geison, 1974; Roll-Hansen, 1979). Soon after the two Bastian's terms, archebiosis and biogenesis, were coined the famous English biologist Thomas Henry Huxley (1825-1895) (Figure 1) introduced the term "abiogenesis". However, in order to avoid further confusion, since his term "abiogenesis" somehow was related to Bastian's term "biogenesis", he adopted the term "biogenesis" for the process where life arises from existing life (Bibby, 1972). Of interest is that the term "abiogenesis" is currently in use to refer to the early physical and chemical events that led to the abiotic formation of biomolecules. This process finally resulted in the first life on Planet Earth, that then evolved over a time span of over 4.0 billion years to the diversification of life as is currently known. Several major ideas or hypotheses about this evolutionary process melted into a combination of Darwin's natural selection, genetic variation and Mendelian inheritance, now designated as neo-Darwinism (Kutschera and Niklas, 2004). These ideas and hypotheses were backed up by numerous (micro)-fossil records, rock isotope-chemistry and broad, though not complete, experimental evidence such as chemical and physical simulation of early Earth conditions, microbial mutation, horizontal gene transfer, and whole genome sequencing.

Spontaneous generation as defined above is now an obsolete proposition, but it was taken for granted for over more than two millennia. The origin of living organisms and life in general has always intrigued mankind as is evidenced from ancient documents as well as from recent research and opinions (Zubay, 2000; Martin and Russel, 2003; Luisi, 2006; Herdewijn and Kusakürek, 2008; Steel and Penny, 2010; Knoll, 2004, 2011; Koonin, 2012). Even the introduction of the microscope and the first viewings of microorganisms in the 17th century, nor the propositions of the germ theory of disease with different agents causing different diseases in the 18th century did not lead to disbelief in SG. It took until the mid-19th century with Louis Pasteur in 1861 and John Tyndall in 1881 to finally disproof experimentally that GS did ever occur!

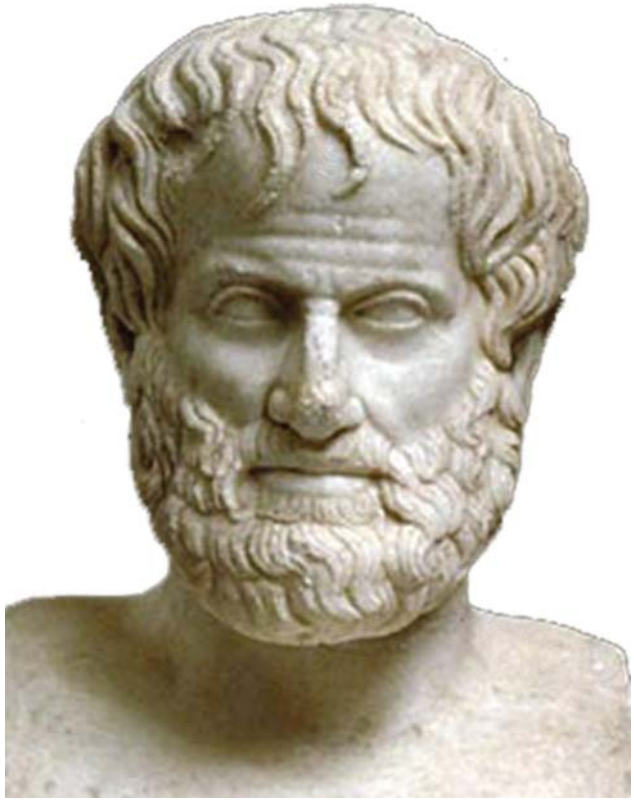

Figure 2: Aristotle (384-322 BC), Greek philosopher and scientist.

The origin and the complex physical/chemical route towards the first ever (microbial) cell on early Earth remains a matter of debate (Bada and Lazcano, 2002; Herdewijn and Kisakürek, 2008; Parker et al., 2011; Jakschitz and Rode, 2012). The evolutionary road from the first protocell to the "*Last Universal Common Ancestor*" or LUCA, now accepted as the most recent common ancestor, that recognizes the three domains of life we know today, involves several steps that remain unresolved (Cantine and Fournier, 2018). Despite this lingering controversy there is quite a general agreement today that LUCA must have had DNA as genetic material, proteins and RNA to catalyze essential processes for growth and reproduction, and a lipid membrane to enclose all its components (Penny and Poole, 1999; Koonin, 2003; Peretó et al., 2004; Lane et al., 2010; Swanson et al.,2016). Before LUCA was formed there was a prebiotic phase, where life's essential molecules and building blocks were generated via a range of random "spontaneous" chemical and physical reactions and interactions, a proposition and process still arousing debate and doubt (Bada and Lazcano, 2002; Steel and Penny, 2010; Knoll, 2011; Swanson et al., 2016; Cantine and Fournier, 2018; Leisola and Witt, 2018).

Figure 3: Jan Swammerdam (1636-1680), Dutch biologist and microscopist

2. ANTIQUITY AND SPONTANEOUS GENERATION

Ancient Chinese recordings from the Shang Dynasty (ca.1600-1050 BC) and old Indian documents already mentioned that aphid insects are spontaneously generated from bamboo, and flies are generated from soil. Babylonian clay tablets (1800-600 BC) mentioned that worms were generated from river mud. As to the Western world, the Greek natural philosopher Anaximander of Miletus (610-540 BC) is now recognized as the first to propose in his book "On Physis (Peri Phuseos; On Nature)" that life developed spontaneously from nonliving matter. He believed that all things arose from the elemental nature of the universe (water, earth, fire and air) and that the primal chaos of the universe was eternally in motion and served as a substrate where elemental opposites (wet and dry, hot and cold) generated a terrestrial slime that shaped the many varied plants and animals in the world. His pupil Anaximenes proposed that air was the element that brought life and endowed creatures with motion and thought. The poet and philosopher Xenophanes of Colophon (560-470 BC) described fossil imprints of plants and animals and concluded from his findings that the world had changed when compared to his time, suggesting a cyclic evolving natural world (Mayor, 2001). Empedocles

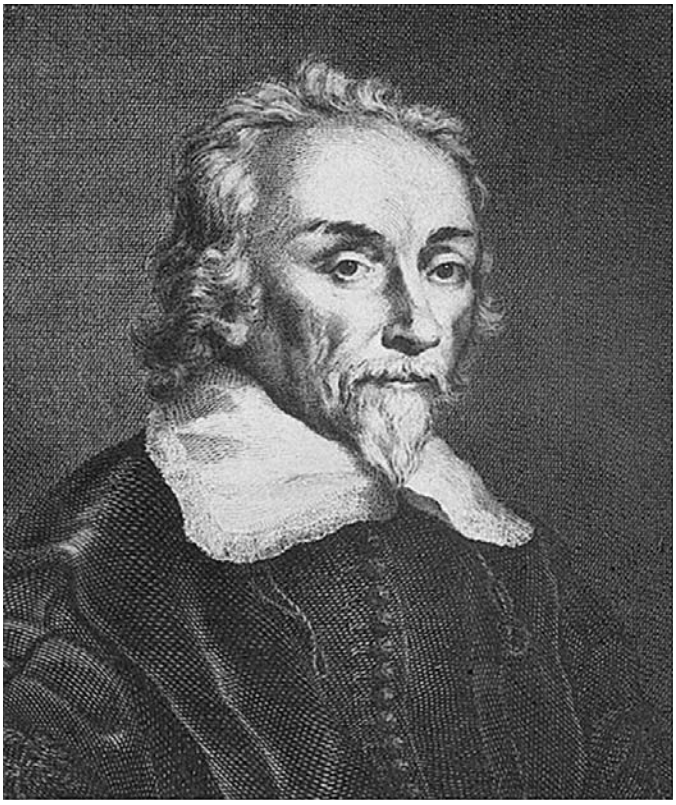

Figure 4: William Harvey (1578-1657), English physician, anatomist and physiologist.

Figure 5: Theodore Schwann (1810-1882), German physiologist.

of Agrigento (480-430 BC) accepted "generatio spontanea" of life also from the four elements, but proposed that water, earth, fire and air had combined in different ways that interchanged over time in cohesion and chaos to yield in the end different life forms (Osborn, 1894; Zirkle, 1941). The famous philosopher and all-round Greek scientist Aristotle (384-322 BC) (Figure 2) theorized extensively on the reproduction of man and animals, whereas his colleague and successor Theophrastus (ca.372-287 BC) specialized in the study of plants and minerals. For example, Aristotle proposed in his books "Historia Animalium" and "De Generatione Animalium" that bivalves and snails were generated from mud, scallops from sand ("abiogenesis") and that eels emerged from earthworms. Of interest is that he discussed sexual and parthenogenetic generation as well. Aristotle's view had an enormous impact and supported a strong belief in SG that lasted throughout the next two millennia (Lehoux, 2017). The Roman author, architect and engineer Marcus Vitruvius Pollio (ca.75-15 BC) advised that libraries be built facing eastwards to benefit from morning sun, not towards the south or the west as those winds generate bookworms. Even as a Christian theologian and philosopher, Saint Augustine of Hippo (354-430 AC) followed this dominant view on SG of the previous philosophers and thinkers. He discussed SG in his books "De Civitate Dei" (The City of God) and "De genesi ad Literam" (The Literal Meaning of Genesis), citing Biblical passages such as "Let the waters bring forth abundantly the moving creatures that have life" as laws that would enable ongoing creation (Fry, 2000).

3. SPONTANEOUS GENERATION DURING THE MIDDLE AGES AND RENAISSANCE

With the fall of the Roman Empire in the 5th century up to the East-West Schism in 1054, the influence of the Greek philosophers and their science declined. However, belief in spontaneous generation as well as in the "miasma" theory proposed by the Greek physician Galen (129-ca. 200 AC) stating that disease transmission was caused by "bad" air or vapor emanating from rotting organic matter stayed on. Aristotle's abiogenesis views were reintroduced into Western Europe in Arabic translation and reached the widest acceptance in the 13th century, when Latin translations became available, also under the influence of theologian, philosopher and jurist Thomas Aquinas (1225-1274). It was discussed in the literature well into the Renaissance (13-16th century), when even William Shakespeare (1564-

Figure 6: Louis Pasteur (1822-1895), French biologist, microbiologist and chemist.

1616) mentioned that snakes and crocodiles were formed from mud of the Nile. However, change was to come based on meticulous studies of the various and differing stages of insect development (egg, larva, pupa and adult). The Dutch biologist and microscopist Jan Swammerdam (1637-1680) (Figure 3) rejected as a first the concept that one animal could spontaneous arise from another one or from putrefaction just by chance and thus he doubted spontaneous generation. However, he associated it with an atheistic view, a fact he could not support (Ruestow, 1985).

4. GRADUAL DISBELIEF IN SPONTANEOUS GENERATION: INFLUENCE OF 16TH TO 18TH CENTURY SCIENTISTS

From the 16th century onwards ancient beliefs were put to the test. The Flemish chemist, physiologist and physician Jan Baptist van Helmont (1580-1644) is considered as one of the first to perform experiments to check natural phenomena. According to him, tree growth was due to water uptake and food was not digested by the body's heat but was aided by a "ferment" within the body (Pagel, 2002). In 1632 the famous English physician, anatomist and physiologist William Harvey (1578-1657) (Figure 4) described blood circulation in the body. He also concluded, based on dissecting pregnant deer, that life originates from invisible eggs, since embryos are not visible during the first month of pregnancy. In his book "Exercitationes de Generatione Animalium", he expressed that everything originates from eggs ("Omnia ex Ovo") (Fry, 2000). Italian physician, biologist and poet Francesco Redi (1626-1697) challenged in 1668 the then still generally believed idea that maggots arose spontaneously from rotting meat by a series of experiments with meat placed in gauze covered open and closed jars. Flies could only enter the open jars and only under those conditions could maggots appear. Then Redi collected them and waited for them to metamorphose into flies. He used his experiments to support the preexistence theory of the Church at that time, stating that living things originate from their parents. He formulated his famous adage "omne vivum ex vivo", all life comes from life. He described in 1684 that parasites of animals produce eggs from which offspring are developed (Fry, 2000; Hawgood, 2003). All these experiments contradicted clearly the prevailing opinion that these small "animals" were spontaneously generated. A few decades later Italian botanist Pier Antonio Micheli

Figure 7: John Tyndall (1820-1883), Irish physicist.

(1679-1737) described in 1729 details characteristic of 1,900 plants and 900 fungi. For instance, he observed that fungal spores, when placed on melon-slices, reproduced the same fungus type that the spores came from. Based on these observations he noted that fungi did not arise from SG. English biologist and priest John Needham (1713-1781) also experimented in 1745 on SG. He believed that boiling broths in flasks would kill all living things, but upon cooling in the open air and subsequent sealing, the broths would cloud (in hindsight by growth of microbes). These findings allowed the belief in SG to persist, despite the microscope becoming available since the 1680s to these early researchers (Needham, 1745). Needham, and also the influential French naturalist George-Louis Leclerc, comte de Buffon, (1707-1788) concluded that there is a life generating force inherent to certain types of inorganic matter that causes living microbes to create themselves over time. It was an Italian priest, biologist and physiologist Lazzaro Spallanzani (1729-1799) who really challenged in 1768 the theory of SG of microbes in modifying Needham's experiment by boiling broths for over one hour in sealed containers (with the air partially evacuated to prevent explosions), with no reappearance of microbes as a result. He proposed that microbes moved in through the air and that they could be killed through boiling (Nordenskiöld,1935). Over time many similar observations demonstrated that, when careful experimentation was followed, biological reproduction was based on existing complex structures rather than on muds and dead material. More proof came in 1837, when independently the German physiologist Theodore Schwann (1810-1882) (Figure 5) and the French inventor and physicist Charles Cagniard de la Tour (1777-1859) discovered yeast and yeast cell division in alcoholic fermentation and by microscopic examination of foam from the beer brewing process. Beer fermentation would not occur if dividing yeast cells were not present. Also, when sterile air was introduced in the beer broth and no yeast cells were present, fermentation would not start. The Dutch scientist Antonie van Leeuwenhoek (1632-1723) had observed in 1680 such "small spherical globules" under his microscope, but did not consider them as living cells. Schwann's observations further damaged the claims at that time that SG was involved in fermentation processes. He had observed that aeration of vessels, filled with broth in the presence of heated air (as oxygen was believed to be essential for SG to occur) prevented microbial growth. He thus concluded that the germs in the air had been destroyed by the heat (Aszmann, 2000).

5. IMPACT OF LOUIS PASTEUR (1822-1895) AND JOHN TYNDALL (1820-1883)

Decisive experiments by Louis Pasteur (Figure 6) and John Tyndall (Figure 7) were to settle forever the over 23 centuries lingering dispute about spontaneous generation. The debate on SG culminated in the late 1850s in France, when the French naturalist Félix Archimède Pouchet (1800-1872), a leading proponent of SG, challenged the views of Theodore Schwann and of Louis Pasteur. Both supported the germ theory, stating that microorganisms/germs arose from germs and those from parents of the same species and also that germs were present everywhere, including in the air and on inanimate matter.

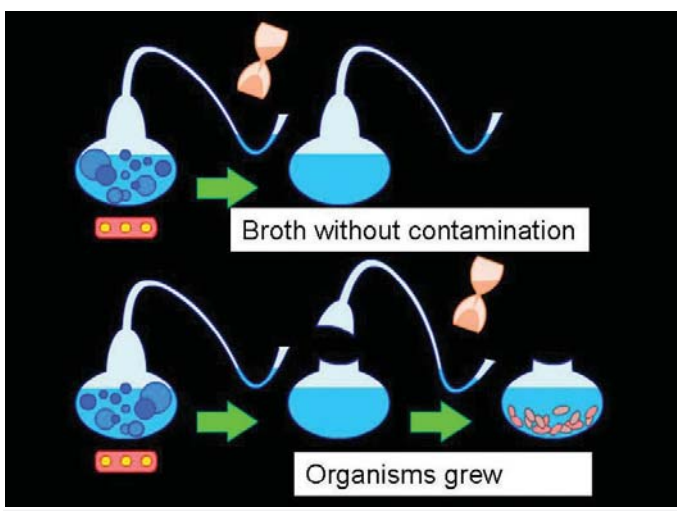

Figure 8: Diagram of Pasteur's swan neck tube experiment.

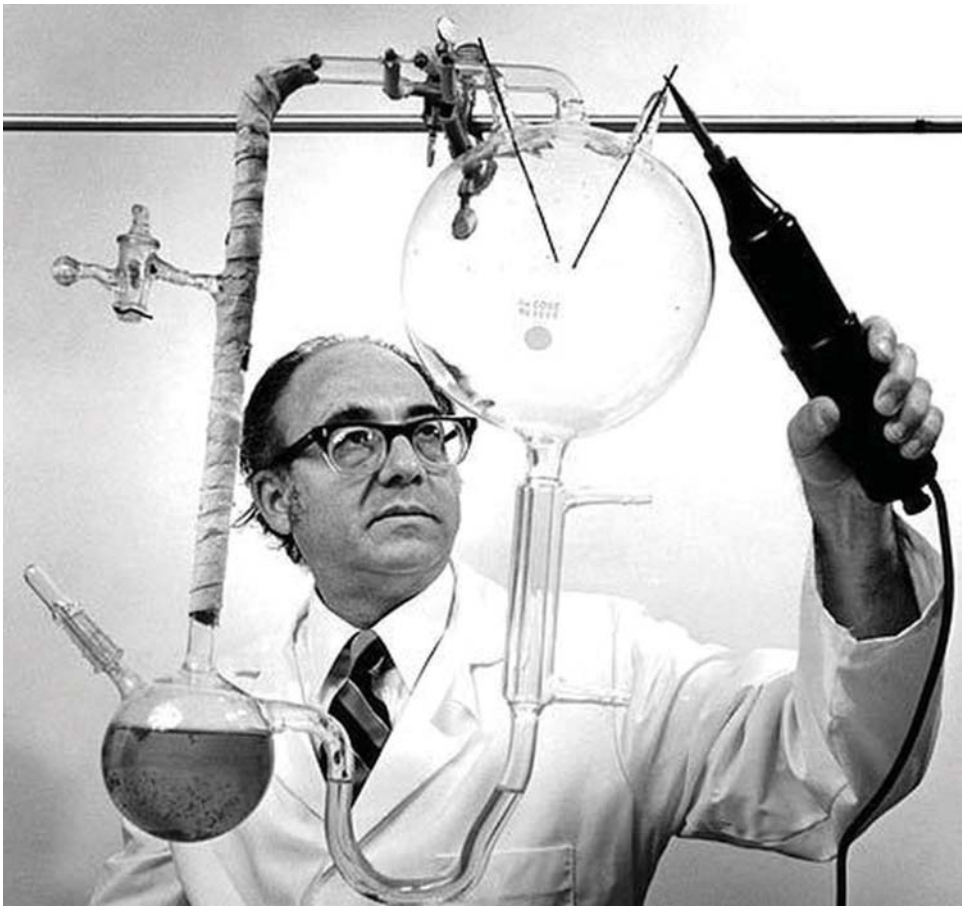

Figure 9: Stanley Miller (1930-2007), American chemist.

Although Pouchet was a renowned animal physiologist, he assumed that living things originated from inanimate matter, including air, calling the process "heterogenesis". In 1858 Pouchet contested Schwann's results based on his own similar experiments. Louis Pasteur wrote to Pouchet in 1859, mentioning that he respected his belief in SG, but that he did not agree with his experimental results because of a poor set up. Despite this criticism Pouchet published in 1859 his major scientific book (in French) "Heterogenesis or Treatise on Spontaneous Generation", endorsing SG in claiming that the eggs of adult organisms are spontaneously generated, not the adults themselves (Farley and Geison, 1974; Roll-Hansen,1979). To solve this controversy, the French Academy of Sciences, in favor of Pasteur's views, established in January 1860 a prize for detailed experimentation that could solve this matter once and forever. Pasteur decided to participate in this competition with the well-known outcome as a result. His sterile broth containing flasks open to the air with a downwards curved swan neck tube (Figure 8) remained sterile for days, until the "air-dust" (particles/spores/ bacteria) collected in the neck was allowed to enter the flasks by purposefully tilting the flask to allow the broth to reach the "dust". Louis Pasteur's famous but "simple" experiments of 1860-1861 are now widely accepted as being decisive for finishing off SG (Dubos,1950; Farley and Geison,1974; Roll-Hansen,1979). Also, the prominent physicist John Tyndall, a correspondent and admirer of Pasteur, further contributed to the complete fall of SG in the period 1876-1881 by developing a method for fractional sterilization, named "Tyndallization" of broths that killed also bacterial endospores, that normally survived boiling as demonstrated in 1876 by Ferdinand Cohn (1828-1898). Tyndall described his experiments in a book "Assays on the Floating Matter of the Air in Relation to Putrefaction and Infection" (Tyndall, 1881; Eve and Creasy,1945). A few years later in 1879, a coworker of Pasteur, Charles Chamberland (1851-1908), developed unglazed porcelain filters, with pores smaller than the size of bacteria (though not the size of viruses), enabling the sterilization of liquids without heating. His research in 1884 also led to the development of the autoclave, now universally in use and essential in research and in industry, related to the microbiology, biotech, fermentation, pharma, medical, food and sanitation sectors.

6. ORIGIN OF FIRST LIFE FROM NON-LIVING MATTER ("ABIOGENESIS" OR PREBIOTIC EVOLUTION) AND SUBSEQUENT EVOLUTION OF LIFE

6.1. EARTH'S PRIMORDIAL SOUP

From the 1920s onwards, hypotheses on the prebiotic evolution were formulated in 1924 by the Soviet biochemist Alexander I. Oparin (1894-1980) as well as in 1929 by the British visionary biologist and statistician John B.S Haldane (1892-1964). The formation of organic biomolecules, such as amino acids, hydroxy acids, aldehydes, and other biomolecules, could have been formed by the effects of atmospheric forces (UV-radiation, lightning, space dust, etc.) or

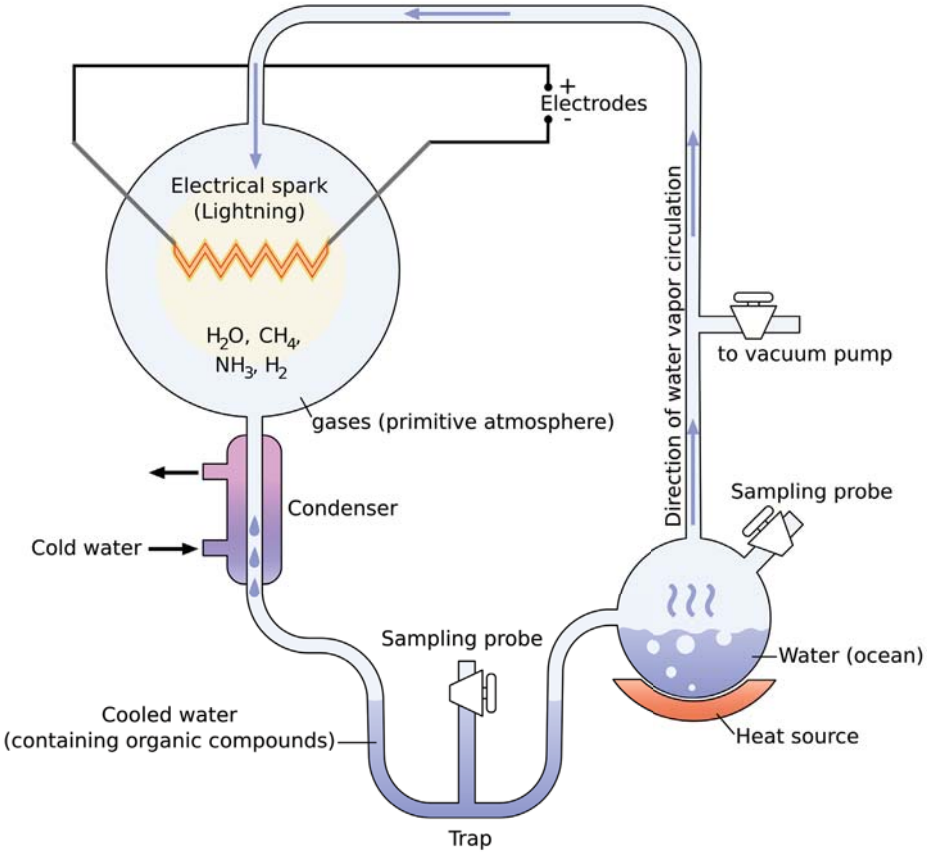

Figure 10: Diagram of Miller's experiment.

volcanic activity on the gases of the prebiotic Earth's atmosphere (methane, ammonia, water, hydrogen sulfide, carbon monoxide, etc.) and/or on abiotic inorganic solutes in superheated thermal vents in the Earth's deep oceans. This theory of the Earth's "primordial soup" being the origin of first life became known as the Oparin-Haldane hypothesis (Oparin,1924; Haldane, 1929; Schopf, 1999, 2002; Yockey, 2005).

This hypothesis was tested in 1953 in a now classical experiment carried out by Stanley L. Miller (1930-2007) (Figure 9) in the laboratory of the Nobel Prize winner Harold C. Urey at the University of Chicago. His experiment, as shown in Figure 10, did confirm that the above-mentioned biomolecules could arise by chemical evolution on the prebiotic Earth (Miller, 1953, 1987). Since then more sophisticated lab experiments and sensitive analyses have provided ample evidence that many chemical components of living cells (amino acids, amines, peptides, ribonucleotides, RNA-like molecules, and others) can form under such harsh conditions (Ring et al., 1972; Powner et al., 2009; Szostak, 2009; Parker et al, 2011; Jakschitz and Rode, 2012). Furthermore, it has been demonstrated that short RNA molecules can indeed act as catalysts (ribozymes) in their own formation as well as in that of other biologically significant reactions such as condensation of amino acids into peptides (as in "modern" ribosomes). Lipid-like compounds in the primordial soup could spontaneously form bilayer structures able to enclose primitive proteins and nucleic acids to form primitive cellular entities or "protocells". The first cells were not as complex as the current microbes and their type of metabolism is unknown. Based on these propositions and facts, it is now generally agreed that the first proto-microorganisms were probably anaerobic chemoautotrophs (Lazcano and Miller, 1996; Martin and Russel, 2003; Knoll, 2004; Luisi, 2006; Herdewijn and Kusakürek, 2008; Steel and Penny, 2010; Mulkidjanian, 2012; Pross, 2012). Anaerobic chemoautotrophic bacteria and archaea (such as acetogens, methanogens, and others), are today still abound on Earth in locations such as in deep sea vents and in volcanic areas. However, these results suggest a long evolution after LUCA.

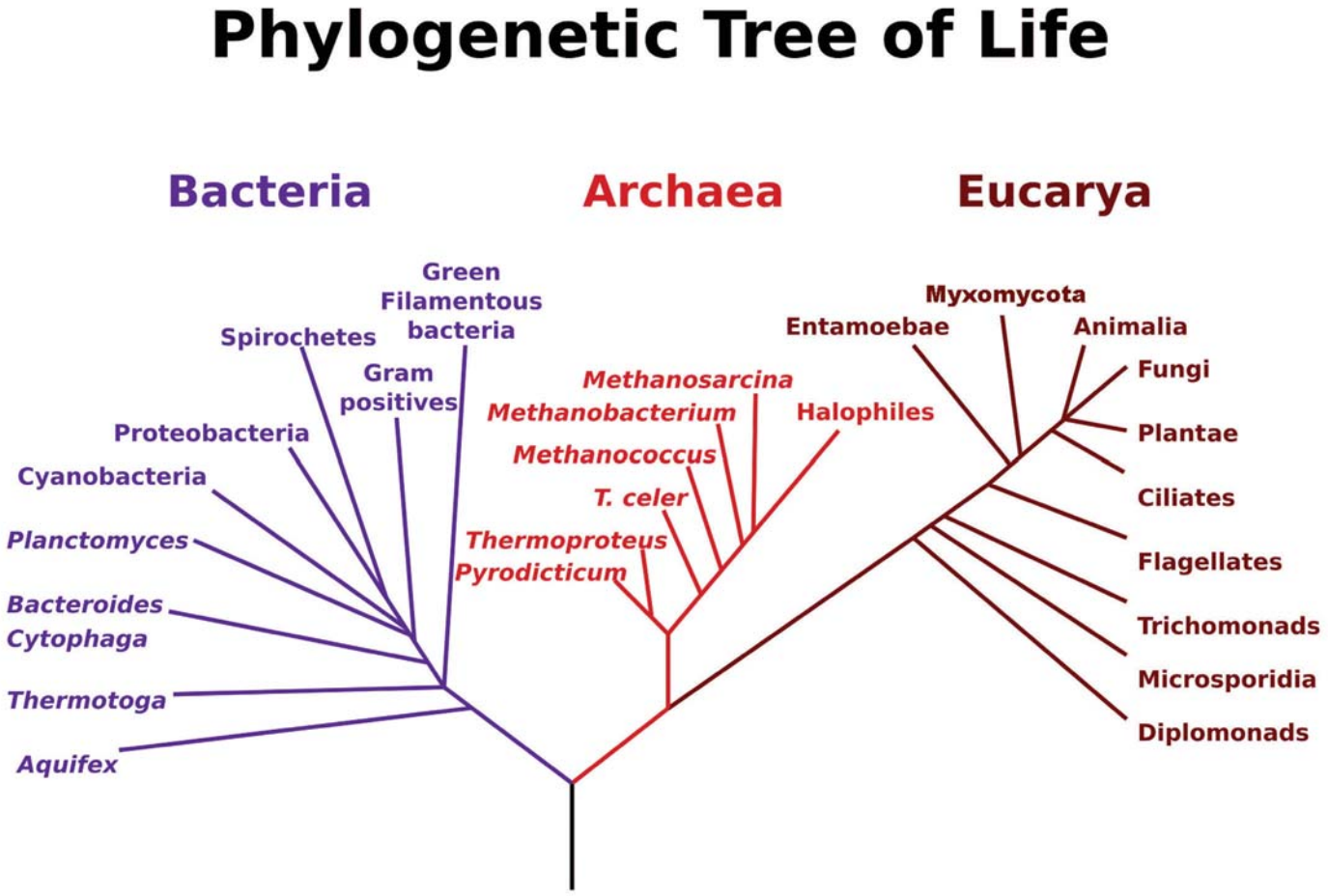

Figure 11: A 1990 phylogenic tree linking all major groups of living organisms to the LUCA (shown as the black trunk at the bottom of the image).

6.2. CURRENT VIEWS ON ORIGIN OF EARLY CELLS (MICROORGANISMS) AND SUBSEQUENT MICROBIAL AND ORGANISMAL EVOLUTION

The Earth was formed about 4.6 billion years ago, then water vapor liquified and oceans formed 4.3 billion years ago, and between this event and 3.85 billion years ago, biological evolution started with no free oxygen present. The first cells probably arose in a reducing atmosphere in hot surroundings and obtained energy from inorganic fuel molecules such as ferrous sulfide (FeS) and ferrous carbonate. This is the "hydrothermal hypothesis" but another mesophilic "lukewarm little pond" hypothesis seems also possible, where the abundance of clay minerals on early Earth could also be important. The organic biomolecules that were needed may have arisen by non-biological reactions described above (Schopf, 1999, 2002; Powner et al, 2009; Jakschitz and Rode, 2012; Mulkidjanian, 2012; Pross, 2012). A scenario, though still controversial, could be that about 3.5 billion years ago, early microorganisms gradually became able to derive energy from compounds in their environment and use that energy to synthesize their own precursor organic molecules.

In 1996 the earliest indication of life, ca. 3.7 - 3.45 billion years old, was proposed, based on forms of graphite-carbon with a distinct biological origin embedded in sedimentary rock, in the Isua supracrustal belt in the Nuuk area in Western Greenland (Rosing, 1999; Ohtomo et al., 2014). A higher level of the lighter isotope 12C-carbon being present in the rock (leaving an isotopic fingerprint) was interpreted as a biological carbon uptake activity. However, this kind of isotopic traces can be produced by abiotic processes and are not unambiguous traces of life. The earliest putative claimed lifeforms are fossilized tubular shaped microorganisms, found in 2017 in 4.28 billion years old iron and silica rich rocks that were once hydrothermal vents in the Nuvvuagittuq greenstone belt in Quebec, Canada (Dodd et al., 2017). However here again, the biogenicity

of these fossilized tubes is controversial and even the age of the successions is still under discussion. A further significant evolutionary step was the development of pigments capable of capturing energy from sunlight, to be used to reduce CO2 to more complex organic compounds. This photosynthetic process initially used H2S as electron donor yielding elemental sulfur or sulfate as byproducts. In rocks that are 3.5 billion years old or younger, fossilized microbial formations called stromatolites are quite common. They consist of mats of layers of probably filamentous anoxygenic photobacteria, although no unambiguous microfossils have been found (Allwood et al., 2009; Sugitani et al., 2015; Knoll et al., 2016). Microfossils have been found that are about 3.45 and 3.2 billion years old but their identity and metabolism are still unknown. Around 2.45 billion years ago, and perhaps earlier, some cells developed the capacity to use H2O as electron donor, liberating O2 as "waste". Cyanobacteria are the descendants of these early oxygenic photosynthetic bacteria that gradually brought oxygen in the Earth's atmosphere. With the development of an atmosphere enriched in oxygen by cyanobacteria, aerobic bacteria appeared that were able to obtain energy by passing electrons from fuel molecules to oxygen (Javaux et al., 2001; Javaux, 2011; Knoll et al., 2016). Starting 1.7-1.5 billion years ago, fossil records show evidence of larger and more complex organisms, the earliest eukaryotic cells, still being unicellular. DNA-protein complexes ("chromosomes") were formed and intracellular compartmentalization stabilized the cell content (Javaux et al., 2001; Javaux, 2011). Recently in July 2018, at the Australian National University, Canberra, scientists reported the presence of intact porphyrin photopigments that are typical for cyanobacteria in marine black shale sedimentary rock of the Taoudeni Basin in Mauritanian Sahara, Africa. These rocks dated as being 1.1 billion years old, which is 600 million years older than reported in previous findings (Gueneli et al., 2018). At that time period, the oceans of the Earth were redox stratified and virtually devoid of multicellular animal life, but early eukaryotes, such as multicellular red microalgae, were already diversifying and their microfossils were preserved in the same sediments (Beghin et al., 2017). The nitrogen isotopic values of the fossil pigments showed that the oceans were dominated by cyanobacteria, while larger planktonic algae were scarce. Based on fossil carotenoid pigments, anoxygenic green (*Chlorobiaceae*) and purple sulfur bacteria (*Chromatiaceae*) also contributed to photosynthesis. Furthermore, a lack of diagnostic eukaryotic steranes in the time interval of 1.6 -1.0 billion years ago, demonstrated that algae did not yet play a significant role in these mid-Proterozoic oceans (Gueneli et al., 2018).

These fossil records indicate that bacterial life dominated planet Earth for about the first 3 billion years, until larger planktonic algae and then metazoans appeared. These recent findings support the hypothesis that small bacterial cells then at the base of the food chain limited the flow of energy to higher trophic levels, potentially retarding the emergence of more complex multicellular life forms, such as animals, that appeared only 0.8 to 0.6 billion years ago. Despite these recent findings, it remains difficult to establish the link between primary bacterial production and the late proliferation of larger and complex organisms because the mid-Proterozoic rock record (1.8 billion and 800 million years ago) is nearly devoid of recognizable phytoplankton fossils.

More than 1.1 billion years ago, early eukaryotic cells had enveloped aerobic or facultative anaerobic protobacteria and photosynthetic cyanobacteria to form endosymbiosis associations that became permanent and led to mitochondria of modern eukaryotes and the chloroplasts of algae and plants, respectively (Margulis, 1996; Margulis and Schwartz, 2001). At much later stages, less than 1.0 billion years ago, unicellular organisms clustered together to gain efficiency. This led eventually quite late, at about 0.8 to 0.6 billion years ago, to the first highly differentiated metazoan organisms as we know them today. In parallel today, bacteria and archaea continue to inhabit every ecological niche in the biosphere and evolve and adapt even to manmade conditions quickly.

6.3. TREE OF LIFE OR RING/WEB OF LIFE?

The enormous abundance of microbes on Earth is a result of their long evolutionary path. Proof of shared ancestry is the fact that all existing organisms, including humans, contain footprints of a unique ancestor in their DNA. The most useful DNA sequences to reconstruct the evolution of life on Earth are those that encode processes shared by all life forms, such as ribosome mediated protein synthesis. Based on this principle, DNA sequencing technology and comparing 16S rRNA genes and their mutations, pioneers Carl R. Woese (1928-2012) and George E. Fox (born in 1945) proposed in 1977 the now iconic three-domain "*tree of life*", reconstructing the evolutionary history (phylogeny) of various micro- and macro-organisms, leading to three distinct evolutionary groups (domains): *Bacteria, Archaea* and

Eukarya (Fox et al., 1977; Woese et al., 1990; Woese, 2002, 2004). In the meantime, many other genes have been used to reconstruct the genealogy of all life forms based on the accumulation of mutations in the target genes and all data support the tree domain view, with an early branching of *Bacteria* and *Archaea* lineages and the branching of *Eukarya* from the *Archaea* lineage (Spang et al., 2015).

Recently with entire genome sequencing technology becoming widely available, whole genomes can be sequenced and analyzed rapidly and inexpensively. This technology allows the consideration of not only mutational changes of rRNA-genes, but also horizontal gene transfer (lateral exchange of genetic material among organisms) as a major driver for genetic variation. Such genome-scale phylogenetic studies support now a "*ring of life*" or "*web of life*" model, whereby *Eukarya* are no longer a primary lineage but form a chimeric group of a symbiotic origin from the *Bacteria* and *Archaea* lineages, even with the noncellular viruses involved or with viruses as a distinct but a parallel world to cells (Koonin, 2012; Swithers and Katz, 2013; Swanson et al., 2016). This "ring/web of life" reconciles the genomic data by positioning the *Bacteria* and the *Archaea* as the two primary and ancient lineages evolved from a common "LUCA" ancestor. The *Eukarya* are then seen as a hybrid group that evolved from the *Bacteria* and the *Archaea* after their diversification had already started.

7. CONCLUSIONS AND PERSPECTIVES

From the above condensed summary of old and recent fossil records, science based hypotheses, advanced laboratory experiments, and recent whole genome scale analyses, it is clear that the proposed events leading to the origin of first life on Earth are quite logical. However, the proposed events are not yet resolved in detail, nor is the subsequent evolution of prokaryotic life towards multicellular eukaryotic organisms understood. In addition, several scientific ideas are still circulating with ever more and more facts accumulating to build on these proposed events. It is now widely accepted that all life today evolved from a common ancestor, a primitive lifeform (LUCA) based on a natural process about 4.3 to 3.5 billion years ago (Figure 11). It is not yet resolved whether "genetics" based on the RNA-world hypothesis, being the most popular hypothesis today, came first. Or instead was it the protein world hypothesis with focus on proteins and metabolism? Also, not resolved is how membraned cells developed (Gesteland et al., 2006; Yarus, 2002; Müller, 2006; McGary and Nudler, 2013; McInerney et al., 2014). Especially the gaps in fossil records, lacunae in proof by chemical and physical experimentation, and biased hypotheses led certain religious and intellectual groups to advocate "creationism" or "intelligent design (ID)", believing that first life and later evolution came about through an intervening designer, creator or god (Leisola and Witt, 2018). Spontaneous and random early physical and chemical reactions on early Earth must have been instrumental over one billion years for the first form of life to appear. Therefore, it is difficult to reconcile "spontaneous generation" as outlined above with the ever-increasing scientific evidence for how the first form(s) of life evolved (Boudry et al., 2010; Koonin, 2012; Pross, 2012; McInerney et al., 2014).

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Dr. Jo Handelsman is the Director of the Wisconsin Institute for Discovery at the University of Wisconsin-Madison, a Vilas Research Professor, and Howard Hughes Medical Institute Professor. She previously served as a science advisor to President Barack Obama as the Associate Director for Science at the White House Office of Science and Technology Policy (OSTP) where she served for three years until January 2017, and was on the faculty at the University of Wisconsin and Yale University before that. She received her Ph.D. at the University of Wisconsin-Madison in Molecular Biology and has since authored over 100 papers, 30 editorials and 5 books. She is responsible for groundbreaking studies in microbial communication and work in the field of metagenomics. She is also widely recognized for her contributions to science education and diversity in science. Notably, she received the Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring from President Obama in 2011, and in 2012, Nature named her one of "ten people who mattered this year" for her research on gender bias in science.

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Two diversity travel awards are available. Apply by August 14, 2019.

RAFT® 2019: Delivering Innovative Fermentation Products: Organism and Process

TIFFANY D RAU, PHD
2019 RAFT PROGRAM CHAIR

The Recent Advances in Fermentation Technology (RAFT®) 2019 meeting will encompass the many aspects that go into producing a product through fermentation from organism design to commercial manufacturing. The RAFT® meeting takes place every two years and is not to be missed for those who have been in the fermentation industry for years or those just starting. The conference will be located for the second time at the Hyatt Regency Hotel in Bonita Springs, FL and will take place from Oct 27 to Oct 30 2019. There will be a preconference workshop on Saturday, October 26 entitled "Fermentation concepts with advanced applications" and will include a number of topics. Interpretation of fermentation data, using off-gas data to make process decisions, medium design concepts, mixing and mass transfer, scale-up and scale down and advanced process troubleshooting techniques are just a few of the topics that will be covered during the workshop. The RAFT® meeting will continue to be single track this year and consist of oral and round table sessions, poster sessions, conference lunches and dinners, two poster sessions and a table top exhibit area.

The session topics along with abstracts written by the conveners follows and the RAFT® organizing team looks forward to individuals participating in the conference.

Bench to the manufacturing suite: Scale-up, tech transfer

Commercialization of fermentation processes often involves scaling from very small volumes (~ 1 mL) to thousands of liters. Many parameters important to fermentation do not scale in a straight-forward manner and can be difficult to measure at large scale. This of course makes fermentation scale-up both challenging and rewarding when solved. Some of these challenges include differences in oxygen transfer, mixing, shear, raw materials, measurement systems, heterogeneity, and equipment capability. This session will give scientists and engineers a chance to share their research, experiences, and insights into delivering a process to the marketplace and sustaining that process after commercialization.

Conveners

Frank Agbogbo – Cytovance Biologics
Chris Stowers – Corteva Agriscience

Continuous manufacturing: Opportunities and limitations

Continuous Manufacturing is a relatively new and emerging field in the area of industrial fermentation, although well implemented in many other fields such as the oil, power, food and chemical industries.

The session welcomes contributions presenting both the opportunities and limitations of continuous bioprocesses. Opportunities and advantages of continuous manufacturing can include, for example: reduced plant size, increased consistency, reduced operation cost, single use (disposable) bioreactors, and more. Challenges and limitations met when trying to import this system can include fitness of Continuous Manufacturing to the Biotech and Pharmaceutical industries: for instance in the development of proper scale-down models, identification of stable clones, control of contamination, linking upstream processes to downstream processes, level of productivity, batch definition, regulatory issues and more.

Conveners

Ghil Jona – Weitzmann
Farzaneh Rezaei – Pivot Bio
Johan Westman – Chr Hansen

Cell factory design and engineering

With the advent of a more holistic approach in bioprocess development, cell factory design and engineering have reached the next level of sophistication. Systems-driven target identification and the widespread use of genome editing tools and automated HT scale-down systems, have enabled industry and academia to accelerate the design of optimized cell factories. This applies equally to classical microbial workhorses such as E. coli and S. cerevisiae, mammalian expression systems and novel hosts. However, the full benefit of these new workflows can only be harvested when critical product quality attributes and other regulatory requirements, eg. strain stability, also can be addressed in a high-throughput manner during the early stages of development. This session aims at showcasing recent advances in the development of microbial and mammalian expression systems and the methods used for screening to develop high-quality and high-titer processes for the production of recombinant proteins and value-added chemicals.

Conveners

Peter Becker – Glycom Denmark A/S
Shushil Machhi – Medimmune
Haitao Zhang – Bayer

Lessons learned, best practices, and case studies in fermentation – Opportunities, challenges and overcoming them – Round Table

With recent advances in microbial strain development technologies, fermentation derived products are increasingly impacting diverse industries from pharmaceuticals, fuels and chemicals to food, textiles and personal care. This explosive growth in fermentation technology brings with it an improved understanding of best practices, key challenges and ideas on overcoming them. Whether it is variation in raw material quality, reliability of mathematical models, the small number of available direct process measurements, or dealing with contamination, partners or regulations, there are several challenges we have all faced in the course of scaling up and commercialization. In this session, we want to highlight some such challenges, discuss how to overcome them and identify opportunities for continued impact of fermentation processes.

Conveners

Katelijne Bekers – Ohly
Smita Shankar – Impossible Foods

Big data, AI and machine learning – Disruption in strain engineering and bioprocess development

Fast computation and inexpensive DNA synthesis enables opportunities to improve the design-build-test cycle in strain engineering and fermentation. Genomics and proteomics data are mined for potential metabolic pathways. Large, parallel, miniaturized experiments test numerous hypotheses in the microbial and fermentation design space and feed machine-learning models. Metabolic modeling and simulations can identify novel pathways, create genetic regulatory networks, and drive improvements in gene expression. High throughput fermentation platforms drive process optimization and media screening while generating data for modeling and process development. This wealth of information requires

improvements in data analysis and decision making. This session will address recent uses of big data, AI, and machine learning towards improvements in strain and fermentation.

Conveners
Keith Alsaker – Evonik
Ashish Sharma – NIH
Firehiwat Tachea – Culture Biosciences

When the revolution comes: Matching supply and demand at the confluence of synbio, industrial biotech and manufacturing – Round Table

Supply and demand of manufacturing capacity is a critical factor in the growth of the Bioeconomy. On the demand side developers are often small companies with limited budgets developing drop in replacements in competition with powerful incumbents, or disruptive products where market pull is not established. In either case sales volumes and timing are notoriously difficult to establish. On the supply side contract manufacturing of bio-products is challenging partly due to the variety of process requirements, the large CAPEX and operational investment required to service clients and by the lack of market certainty.

Consequently, developers often struggle to raise finance due to limited manufacturing options, while contract manufacturers (CMOs) are unable to invest in capacity due to the inability of those developers to commit. This is a chicken and egg situation that is hampering the commercial penetration of biological products. With the rapid advances being made by synbio exponents and increased market pull for biobased and biodegradable materials will we suffer an enormous production capacity shortage or will CMOs be left sitting on empty assets?

This session will bring together industry experts from both sides of the fence to present their visions of the future and to debate the challenges and needs. The audience can participate fully with lively and thoughtful discussion and through a questionnaire that will be used to inform the discussion. We will seek to provide some clarity to the question of manufacturing capacity demand. CMOs and product developers are invited to submit abstracts to an associated poster session to inform the conference on challenges and production capacity and availability.

Conveners
Tim Davies – Rubus Scientific and RAFT® Co-Chair
Yaoping Zhang – University of Wisconsin – Madison

Please visit the RAFT® website, *www.simbhq.org/raft*, for more information about the conference as well as opportunities to participate as a presenter and/or an attendee.

See you in warm and sunny Florida in October for the RAFT® 2019 meeting!

3rd International Conference on Natural Product Discovery and Development in the Genomic Era

Wyndham San Diego Bayside Hotel
San Diego, CA

January 12–16, 2020
www.simbhq.org/np

A joint meeting with

The Society for Actinomycetes Japan

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Steven Van Lanen, USA
Yeo Joon Yoon, Korea
Wenjun Zhang, USA

Speakers

Keynote Speaker: Jon Clardy, Harvard University
Banquet Speaker: Bill Fenical, Scripps/UCSD

Meeting Schedule

Sunday, January 12

Noon Registration

5-6 pm Keynote lecture

6-8 pm Poster Session/reception

Monday, January 13

I. Natural products of bacterial origin

Conveners: Eung-Soo Kim, Inha University; Catherine Ryan, University of British Columbia

II. Natural products of eukaryotic origin

Conveners: Ikiro Abe, University of Tokyo; Sarah O'Connor, MIT

Poster Session 2

Tuesday, January 14

III. Novel chemistry and enzymology of natural products

Conveners: Greg Challis, University of Warwick; Bo Li, University of North Carolina

IV. Natural product enzymes as biocatalysts

Brad Moore, USCD Scripps; Allison Narayan, University of Michigan

Free evening

Wednesday, January 15

V. Enabling technologies for natural products

Conveners: Nigel Mouncey, JGI and Nathan Magarvey, McMaster University

VI. Natural products for new targets and biology

Conveners; Brian Bachmann, Vanderbilt University; Wenjun Zhang, University of California-Berkeley

Banquet and lecture

Thursday, January 16

VII. Natural product drug discovery and development

Conveners: Rolf Mueller, Saarland University; Carole Bewley, NIH

Adjourn

SIMB Society for Industrial Microbiology and Biotechnology

2019 SIMB Individual Membership Application

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Position/Title

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Highest Degree/Year

Month of Birth (Optional)

Recommended By

What Is Your Area of Expertise? (Check One)

- ☐ Fermentation (non-food or beverage)
- ☐ Cell Culture
- ☐ Metabolic Engineering/Strain Engineering
- ☐ Molecular Biology/Synthetic Biology Tools Development
- ☐ Biocatalysis/Enzymology/Biochemistry/Enzyme Engineering
- ☐ Biomass Pretreatment, Deconstruction, and Conversion
- ☐ Antibiotics/Secondary Metabolites/Natural Products/Pharmaceuticals
- ☐ Microbiome Research/Metagenomics
- ☐ Microbial Control/Biocides & Disinfectants/Clinical & Medical Microbiology
- ☐ Environmental Microbiology/Bioremediation
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- ☐ Brewing, Winemaking, and Fermented Foods
- ☐ Systems Biology, Omics, Computational Biology, and Bioinformatics
- ☐ Process Development & Biochemical Engineering
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- ☐ Marine, Aquatic Biology & Algae
- ☐ Mycology/Fungal Biotechnology
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How Did You Hear About SIMB? (Check One)

- ☐ Colleague/Networking
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- ☐ *Journal of Industrial Microbiology & Biotechnology*
- ☐ Professor
- ☐ SIMB Website
- ☐ SIMB Meeting Attendance
- ☐ Other:_____

What Is Your Primary Occupational Activity? (Check One)

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- ☐ Process and/or Product Development
- ☐ Manufacturing
- ☐ QC/QA & Testing
- ☐ Executive
- ☐ Management
- ☐ Grad Student/Post-doc
- ☐ Sales
- ☐ Consultant
- ☐ Other _____

2019 Calendar Year Dues (January 1–December 31)

Memberships include subscriptions to *SIMB News* (quarterly) and the *Journal of Industrial Microbiology* (monthly). If you join after January 1, you will not receive hard copy back issues of the publications. Print back issues are subject to availability. Back issues are available online.

Note: 2019 memberships are accepted until September 30.

SIMB Membership ☐ New ☐ Renewal

☐ **US Regular**	$110.00
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☐ **Student**	$58.00
☐ **Emeritus** (Contact SIMB for details)	
☐ **Corporate** (Contact SIMB for details)	

Membership Subtotal $ _____

☐ **Consultant Services** add $50.00

Services Subtotal $ _____

Annual Meeting Program

☐ **2019**	$50.00 (no charge to meeting participants)
☐ **2018**	$50.00
☐ **2017**	$25.00
☐ **2016**	$25.00

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Advances in Biopharmaceutical Technology in China, 2nd ed.

International Biopharma Spotlight

Society for Industrial Microbiology and Biotechnology and BioPlan Associates

Advances in Biopharmaceutical Technology, 2nd ed – A new opportunity exists in working with Chinese companies to establish scientific and business partnerships, and to create effective strategies. However, success in Asia will require changes in partnerships between Western and Asian companies.

Every company faces the question "What should our China strategy be?"

This volume, published by **BioPlan Associates, Inc., in cooperation with the Society for Industrial Microbiology and Biotechnology (SIMB)** provides an overview of the biopharmaceutical industry, and the state of technology in China. A peer-reviewed, ready reference for all aspects of biopharmaceuticals in China, including an understanding of the China biopharma current situation, and future opportunities. Readers receive a comprehensive assessment of the state-of-the-industry, trends and analysis. information on all types of organizations involved in biopharma in China, whether they are domestic. multinational or government.

Readers will be able to:

- Assess the state of biopharmaceutical development in China
- Understand general business practices
- Analyze business opportunities and identify potential partners

Published by BioPlan Associates, Inc., and Society for Industrial Microbiology and Biotechnology (SIMB)
October 2018
ISBN: 978-1-934106-34-1

by Elisabeth Elder

Plant-Microbe Interactions in the Rhizosphere

Adam Schikora, editor
Caister Academic Press, UK
ISBN: 978-1—912530-00-7 (paperback)
ISBN: 978-1-912530-01-4 (ebook)
2018

As the editor of *Plant-Microbe Interactions in the Rhizosphere* Adam Schikora pulled together a broad group of contributors representing institutions in France, Germany, Saudi Arabia, and the United Kingdom. The first chapter covers metabolism in the rhizosphere with the major focus being heterotrophic metabolism in bacteria-bacteria interactions and bacteria-plant interactions. Many of the organic substrates metabolized within the rhizosphere are discussed.

The second chapter covers the role of plasmids and horizontal gene transfer in bacteria associated with plants and the roles the plasmids play in bacteria-plant interactions. Functions of plasmids in the rhizosphere, endosphere, and phyllosphere are included as are beneficial and pathogenic traits. Plasmids have been found to be involved in plant responses to biotic and to abiotic stresses. Plasmids have also been found to be involved in antibiotic resistance and heavy metal resistance in bacteria. The presence of these plasmids in enteric organisms could present human health risks if the organisms are consumed on fresh fruits and vegetables.

Chapter three covers plant immunity. The combination of preformed and inducible systems allow plants to be resistant to many pathogens. Preformed plant defenses block pathogen entry and are major mechanisms in defense. When invading microbes are detected the induced defenses come into play. These include microbe-associated molecular pattern (MAMP)-triggered immunity (MIT) which depend on Patter-Recognition Receptors (PPRs) and effector-triggered immunity (ETI) which rely on plant R proteins.

The fourth chapter covers endofungal bacteria which are present in hyphae as well as in spores. Their roles aren't completely understood but may include promotion of plant growth, improvement of plant resistance, as well as decreased loss of yield. Interestingly endofungal bacteria were discovered approximately 40 years ago but few have been isolated and how they enter fungal cells has not been determined.

Chapter five covers the important functions of rhizosphere microbes in plant-nematode interactions. One focus is on hyperparasitic microbes which antagonize phytonematodes and how these interactions may be impacted by crop rotation. Another focus is plant defense systems which are triggered by nematode-associated microbes. This chapter also covers plant-nematode-microbe interactions in integrated pest management.

The final chapter covers apple replant disease (ARD). Many areas worldwide have been planted and replanted for apple production. With subsequent plantings, plant growth is suppressed as are apple yields and apple quality. The causes are poorly understood but include changes in soil properties, faunal vectors, trophic cascades, and changes in secondary metabolism. While soil disinfection is possible, the most likely control will result from improving soil microbial and faunal diversity as well as habitat quality.

Each chapter can stand as an individual unit – the topics are well organized and well supported by references. Each chapter also provides an integral part to the overall book without being redundant. The text is well supported by pertinent charts, tables, and figures. The book will be of particular interest to soil microbiologists, environmental microbiologists, and plant scientists with likely applicability among graduate students and faculty plus researchers in soil conservation, crop rotation, and bioremediation.

Board of Directors election results for 2019

Congratulations to the winners of the 2019 Board of Directors election. The incoming officers will begin their terms at the annual business meeting July 24, 2019.

President-elect

Steve Decker, NREL

Directors

Katy Kao, Texas A&M

Priti Pharyka, Genomatica

Thanks to all who participated in the 2019 election.

The Inception of the SIMB Diversity Committee

by Sara Shields-Menard

In 2014, by direction of then SIMB President Leonard Katz, the Diversity Committee was formed with Susan Bagley, Professor Emeritus at Michigan Technological University (Michigan Tech) (Houghton, MI), and Raul Cano, Professor Emeritus at California Polytechnic State University (San Luis Obispo, CA), leading the way. The mission of the SIMB Diversity Committee is to integrate cultural sensitivity and a commitment to gender, racial and ethnic diversity throughout the organizational structure of SIMB and the broader community of Biotechnology. Current committee members include Sara Shields-Menard (co-chair; Nicholls State University, Thibodaux, LA), Felipe Sarmiento (co-chair; Ginkgo Bioworks, Boston, MA), Laura Jarboe (Iowa State University, Ames, IA), Noel Fong (Nucelis, San Diego, CA), Sheena Becker (Corteva, Wilmington, DE), Ganesh Sriram (University of Maryland, College Park, MD), Nigel Mouncey (ad-hoc; Department of Energy's Joint Genome Institute, Walnut Creek, CA), and Susan Bagley (emeritus co-chair; Michigan Tech).

The phrase "Lift as You Climb" is often used as a metaphor for women to empower other women on their career paths instead of fighting each other to the top. As I wrote this article on Susan Bagley, the outgoing Diversity Committee Chair, and myself, the new co-chair of the Diversity Committee, I thought of that expression. At my first SIMB meeting, I thought, "I have found my people!" Years later, it is still true. As a graduate student I was involved with the Diversity Committee as a member working on communications and travel awards. Now, as Susan's term as co-chair has been completed and I try to fill those shoes, I am grateful for Susan's mentorship, her leadership of this Committee, and paving the way for this new team - truly lifting as she climbed. Through email we discussed our interest in science, diversity in STEM, and the bright future ahead for SIMB. Highlights of those conversations are below.

How did you become interested in science?

SB: My father (a surgeon) was very interested in science, particularly environmental studies. He got his interests from his father, also a surgeon, who was very active in environmental/conservation efforts. I can't remember when I wasn't interested in environment/science but my first formal memory is preparing a project for a 7th grade science fair. My first scientific interest was botany. This was fairly easy to study at the organismal level and was the subject of all of my science fair studies.

SSM: My family obviously had a big impact on my interest in science. I spent many summers on my grandparents' farm in North Louisiana. They knew so much about the land, its native plants and wildlife. It was always interesting to me when they shared their knowledge with me. My dad is an engineer and was always working on things around the house. He would use me and my siblings as his helpers on projects, it was fun to build or fix things. He taught me that there's a process to making something work. My mom, a librarian, encouraged reading and always told me that if I wrote or spoke a word, I should know the meaning of it.

What is your field of STEM and your research focus?

SB: My main area has always been environmental microbiology, defined as dealing with microbes that are potentially of environmental harm or benefit.

SSM: Same! My main research focus has been on environmental microbiology, particularly in biofuels.

Why do you think diversity and inclusion are so important and how has your thinking changed over time?

SB: It may sound trite, but diversity of all types enhances creativity and helps people to work together by having increased understanding and appreciation for other cultures or points of view. My early focus early was mainly on women and diversity. This is in part because most places where I went to school/worked mainly had women as the sole minority. Most STEM areas are also relatively low in women and underrepresented minorities.

SSM: I think diversity and inclusion are important because without it, we are missing out on so many perspectives and talents that could advance really big ideas. My thinking of this has changed in that now I focus more on inclusion. What's the point of bringing a bunch of diverse people to the table if no one feels like they are wanted there? Underrepresented minorities and women are interested in STEM and go into these fields at higher numbers than previously seen, but now we see this cohort of women and minorities not advancing up the ladder.

What is your goal in being on the Diversity Committee?

SB: My personal goal was to have the Committee be so established that the SIMB Board of Directors and membership would embrace and support the Committee's efforts. It was also important to establish a succession plan and have the efforts of the initial group (and co-chairs) would continue.

SSM: My goal is of this Committee is to bring new people to SIMB and give them the stage for their research while exposing the next generation of scientists, grad students and post-docs, to someone who may look like them. One of the great things about SIMB is that it's easy to get involved and approach speakers and senior scientists. This presents an amazing opportunity to facilitate these mentor/mentee relationships. Another goal is to provide programming for people to learn more about best practices on diversity and inclusion concepts so participants can bring these ideas back to their workplace. It's my hope that we're fostering relationships, advancing careers, and providing information that changes workplace behavior.

What accomplishments are you proud of that were initiated by the Diversity Committee?

SB and SSM: We are proud that the Board of Directors has whole-heartedly supported these efforts. We have an entire session devoted to diversity and inclusion, which is not common among other societies and organizations. The graduate travel awards for all SIMB meetings are a tangible achievement. We get to meet these award winners and that's rewarding for us.

What of the future of the Diversity Committee? And SIMB?

SB: I would like to see more meeting attendees at the SIMB-sponsored session, of course. Perhaps getting more corporate interest and support would help publicize the session and perhaps attract attendees who work at these companies. Ideally, we would get to the point where discussions are not about why diversity is important/necessary but cover different practices that are used.

The future of SIMB is still in finding that essential niche that will be indispensable for industrial, academic, and even non-profits. Being a small, more focused society should be to SIMB's advantage. I don't think it is a surprise to anyone that some of the much larger applied microbiology societies are not necessarily considered relevant. Given the global importance of what SIMB covers, it seems that links with similar groups outside the US should be expanded. It is also important to attract younger/more diverse membership/meeting attendees to help keep the Society highly relevant for now and the future.

SSM: I agree with Susan. We have made progress in advancing the importance of diversity and inclusion, but it would be great to be at a place where students, faculty, and industry scientists are sharing ideas and tools. I would also like to see the development of a mentorship program and for SIMB to grow in membership.

What are your hobbies outside of science?

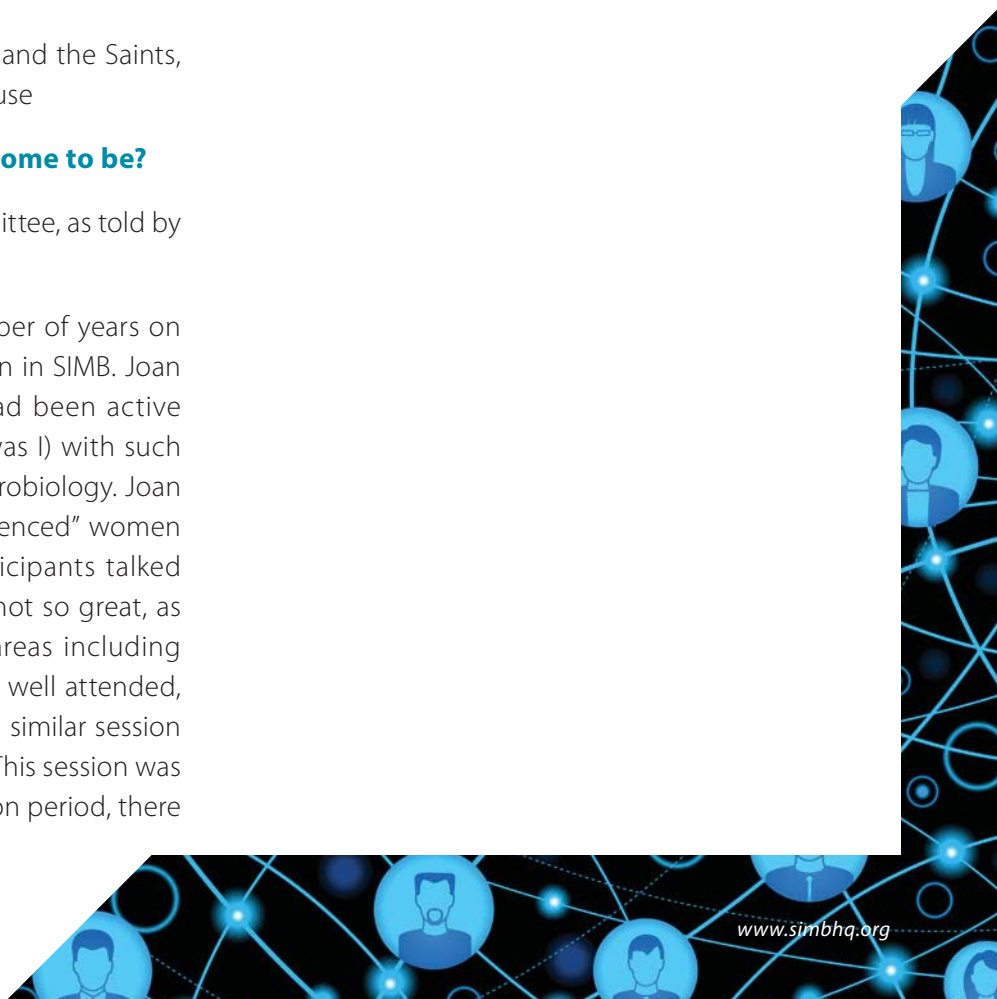
SB: Traveling, birding, boating, fishing

SSM: Traveling, watching the Pelicans and the Saints, going to festivals, and renovating a house

How did the Diversity Committee come to be?

The origins of the SIMB Diversity Committee, as told by Susan Bagley (former Co-chair):

There had been discussion for a number of years on having formal efforts related to women in SIMB. Joan Bennett and other SIMB members had been active in this area and were also active (as was I) with such efforts in the American Society for Microbiology. Joan organized a session with "more experienced" women for a SIMB Meeting wherein the participants talked about their experiences – great, and not so great, as women in science and other STEM areas including what mentors each had. This was very well attended, and interest was expressed in having a similar session but with women early in their careers. This session was also very well–received. In the discussion period, there was considerable interest in forming a committee to consider women's concerns and issues. I proposed to Leonard Katz, the incoming SIMB President, that a Presidential ad-hoc Committee be formed to discuss establishing a "Women in SIMB" committee and to report back to the President and Board of Directors in the next year. Leonard surprised me by announcing in his opening remarks as President that he was establishing a Diversity Committee with me as Chair. This was a bit of a game-changer as I did not feel qualified to represent all areas of diversity. There had been discussion of having a separate "underrepresented minority" committee once we had a framework for the women's committee. Fortunately, Raul Cano, who had extensive experience in other areas, agreed to be co-chair of this new committee. In 2014, we developed the vision, mission, and goals, recruited members, and we were off and running.



Meetings & Continuing Education

SIMB Meetings

July 21–24, 2019	SIMB Annual Meeting and Exhibition	Marriott Wardman Park Washington, D.C. *www.simbhq.org/annual*
October 27–30, 2019	Recent Advances in Fermentation Technology (RAFT®)	Hyatt Regency Coconut Point Ft. Myers, FL *www.simbhq.org/raft*
January 12-16, 2020	3rd International Conference on Natural Products Discovery and Development in the Genomic Era	Wyndham San Diego Bayside Hotel San Diego, CA *www.simbhq.org/np*
April 26-29, 2020	42nd Symposium on Biotechnology for Fuels and Chemicals	Astor Crowne Plaza New Orleans, LA *www.simbhq.org/sbfc*
August 9-12, 2020	SIMB 70th Annual Meeting and Exhibition	Hyatt Regency San Francisco San Francisco, CA *www.simbhq.org/annual*

Other Industry Meetings

July 28, 2019	Natural Products and Bioactive Compounds - GRC	Andover, NH *https://www.grc.org*
August 26-27, 2019	Environmental Microbiology and Public Health Microbiology	Toronto, Canada *http://www.lexisconferences.com*
September 3-6, 2019	ASM/ESCMID Conferences on Drug Development to Meet the Challenge Of Antimicrobial Resistances	Boston, MA *https://asm.org/Events*
September 27-28, 2019	3rd International Conference on Microbes and Beneficial Microbes	Toronto, Canada *https://beneficialmicrobes.conferences.com*

SIMB Committees 2018–2019

Committee	Chair	Email	Term expires	Members	Staff Liason
Annual Meeting 2019	Katy Kao	*katy.simb.2019@gmail.com*	2019	See Program Committee	Tina Hockaday, Chris Lowe
Archives	Debbie Chadick	*dchadick@embarqmail.com*	2022	Paul Cino, Doug Eveleigh, Ann Kulback	Jennifer Johnson
Awards/Honors	Mahendra Jain	*mahendra3950@gmail.com*	2021	Kenneth Bruno, Kathy Asleson Dundon, Tom Jeffries, Raj Boopathy	Chris Lowe
Audit & Investment Advisory	Jeff Schwartz Herb Ward	*JLSmicro@aol.com* *wardch@rice.edu*	2020 2020	George Garrity	Chris Lowe, Espie Montesa
Diversity	Sara Shields-Menard Felipe Sarmiento	*sara.shieldsmenard@gmail.com* *felipe.sarmientob@gmail.com*	2021 2020	Noel Fong, Laura Jarboe, Sheena Becker, Vanessa Nepomuceno	Jennifer Johnson, Chris Lowe
Education and Outreach	Joy Doran-Peterson	*joydoranpeterson@gmail.com*	2020	Mark Berge, Stephanie Gleason, Noel Fong, Laura Jarboe, Jeni Ton, Steve Van Dien	Chris Lowe
Elections	Kristien Mortelmans	*kristien.mortelmans@sri.com*	2019	Badal Saha	Jennifer Johnson
Exhibits	Elisabeth Elder	*elisabeth.elder@gsw.edu*	2021	Lisa Soto, Bob Berger, Abbie More	Tina Hockaday
Finance	Laura Jarboe	*ljarboe@iastate.edu*	2020	Finance Committee	Chris Lowe
Meeting Sites	Chris Lowe	*chris.lowe@simbhq.org*	-	BOD and meeting chairs	
Corporate Member Outreach	Andreas Schirmer	*andreas.schirmer@REGI.com*	2020	Don Hahn, Corteva; Jonathan Sheridan, Teslagen	Jennifer Johnson
	Yoram Barak	*yoram.barak@basf.com*	2020		
Membership-individual	Stephanie Gleason	*slgleaso@gmail.com*	2021	Laura Jarboe, Thomas Klasson, Steve Van Dien	Jennifer Johnson
Nominations	George Garrity	*garrity@namesforlife.com*	2019	Nigel Mouncey, Thomas Klasson, Yoram Barak, Kristala Jones Prather	Chris Lowe
Placement	Bob Berger	*bbberg@att.net*	2020	Sara Dorman	Jennifer Johnson
Planning	Janet Westpheling	*janwest@uga.edu*	2019		Chris Lowe
Publications	Nigel Mouncey	*njmouncey@gmail.com*	2020	George Garrity, Herb Ward	Chris Lowe
JIMB	Ramon Gonzalez	*ramon.gonzalez@usf.edu*	2020	*JIMB Editors*	
SIMB News	Melanie Mormile	*mmormile@mst.edu*	2024	Kristien Mortelmans, Elisabeth Elder, Vanessa Neopmuceno	Katherine Devins
Presidential Ad Hoc Committees-expire 2019					
Ethics Committee	Susan Bagley	*stbagley@mtu.edu*	2019	Scott Baker, Neal Connors	
International Outreach	Susanne Kleff	*kleff@msu.edu*	2019	Scott Baker, Tim Davies, George Garrity, Peter Punt, Thomas Klasson, Erick Vandamme, Michael Resch	

Special Conferences			Term
SBFC 2020	Claus Felby	*cfe@novo.dk*	*2021*
	Scott Baker	*scottbaker@pnl.gov*	*2022*
	Seema Singh	*ssingh@lbl.gov*	*2019*
NP 2020	Ben Shen	*shenb@scripps.edu*	*2020*
	BrianBachmann	*brian.bachmann@Vanderbilt.Edu*	*2020*
	Nigel Mouncey	*nmouncey@lbl.gov*	*2020*
	Yi Tang	*yitang@ucla.edu*	*2020*
RAFT® 2019	Tim Davies	*tim.davies@rubusscientific.com*	*2019*
	Tiffany Rau	-	*2019*

Become a SIMB Corporate Member

Member Benefits:

• Meeting Registration Discounts (Each $500 voucher is good toward any SIMB meeting registration fee)

Silver - 1 $500 voucher

Gold – 2 vouchers

Diamond - 3 vouchers

Other Current Benefits:

• Recognition and corporate profile in *SIMB News*

• Discounted exhibit booths

• Discounted advertisements and job postings

SIMB | Society for Industrial Microbiology and Biotechnology

2019 SIMB Corporate Membership Application

Choose Your Corporate Level:

☐ Institutional Level $700	☐ Bronze Level $500	☐ Silver Level $1000	☐ Gold Level $1,500	☐ Diamond Level $2,500

Name of Company: _____

Company Website: _____

Company Description (50 words or less): _____

_____

_____

Social Media Handle(s): _____

** Gold and Diamond Levels - Send company logo to *membership@simbhq.org*

How Did You Hear About SIMB?

- ☐ Colleague/Networking
- ☐ SIMB Meeting Announcement
- ☐ Direct Mail
- ☐ *SIMB News*
- ☐ Social Networking
- ☐ SIMB Local Section
- ☐ SIMB Member
- ☐ *JIMB*
- ☐ SIMB Website
- ☐ SIMB Meeting Attendance
- ☐ Other: _____

Choose Your Industry Segment:

- ☐ Fermentation (non-food or beverage)
- ☐ Cell Culture
- ☐ Metabolic Engineering/Strain Engineering
- ☐ Molecular Biology/Synthetic Biology Tools Development
- ☐ Biocatalysis/Enzymology/Biochemistry/Enzyme Engineering
- ☐ Biomass Pretreatment, Deconstruction, and Conversion
- ☐ Antibiotics/Secondary Metabolites/Natural Products/Pharmaceuticals
- ☐ Microbiome Research/ Metagenomic
- ☐ Microbial Control/Biocides and Disinfectants/Clinical & Medical Microbiology
- ☐ Environmental Microbiology/ Bioremediation
- ☐ Food Microbiology and Safety
- ☐ Brewing, Winemaking, and Fermented Foods
- ☐ Systems Biology, Omics, Computational Biology, and Bioinformatics
- ☐ Process Development & Biochemical Engineering
- ☐ Agriculture/Plant Biology
- ☐ Marine, Aquatic Biology & Algae
- ☐ Mycology/Fungal Biotechnology
- ☐ Analytical Chemistry, QA/QC
- ☐ Regulatory Affairs, IP, and Sustainability
- ☐ Other: _____

Payment

Federal Tax ID# 35-6026526

Total Amount Enclosed $ _____

☐ Invoice my company ☐ Check enclosed (payable to SIMB). Check must be drawn from a US bank.
☐ Charge to: ◯ Visa ◯ MC ◯ AMEX
☐ Wire Transfer (Additional Fees Apply)

Card #: _____

Exp. Date: _____

Signature: _____

Name on Card: _____

Authoring Officer who is to receive all billing information:

Name: _____

Title: _____

Address: _____

City/State/Zip: _____

Country: _____

P: _____ F: _____

Email: _____

(see page 2 for company representative form)

Send Payment To:

Society for Industrial Microbiology & Biotechnology • 3929 Old Lee Highway Suite 92A • Fairfax VA 22030-2421
P: 703.691.3357 x23 • F: 703.691.7991 • E: membership@simbhq.org • www.simbhq.org

SIMB Society for Industrial Microbiology and Biotechnology

2019 SIMB Corporate Membership Application

Company Representative who will receive membership including publications:

☐ Please do not send me SIMB information via email
☐ Please do not include me on any SIMB mailing lists
☐ Please do not include my information in the SIMB online membership directory

Please Select a Delivery Method for both *JIMB* and *SIMB News*

☐ *SIMB News* MAIL Print Copy
☐ *SIMB News* Online Access ONLY

☐ *JIMB* MAIL Print Copy
☐ *JIMB* Online Access ONLY

Name:

Title:

Address:

City/State/Zip:

Country:

P: F:

Email:

Additional Company Representative (Gold and Diamond Level only)

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Title:

Address:

City/State/Zip:

Country:

P: F:

Email:

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☐ *JIMB* Online Access ONLY

Name:

Title:

Address:

City/State/Zip:

Country:

P: F:

Email:

Additional Company Representative (Diamond Level only)

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☐ *JIMB* Online Access ONLY

Name:

Title:

Address:

City/State/Zip:

Country:

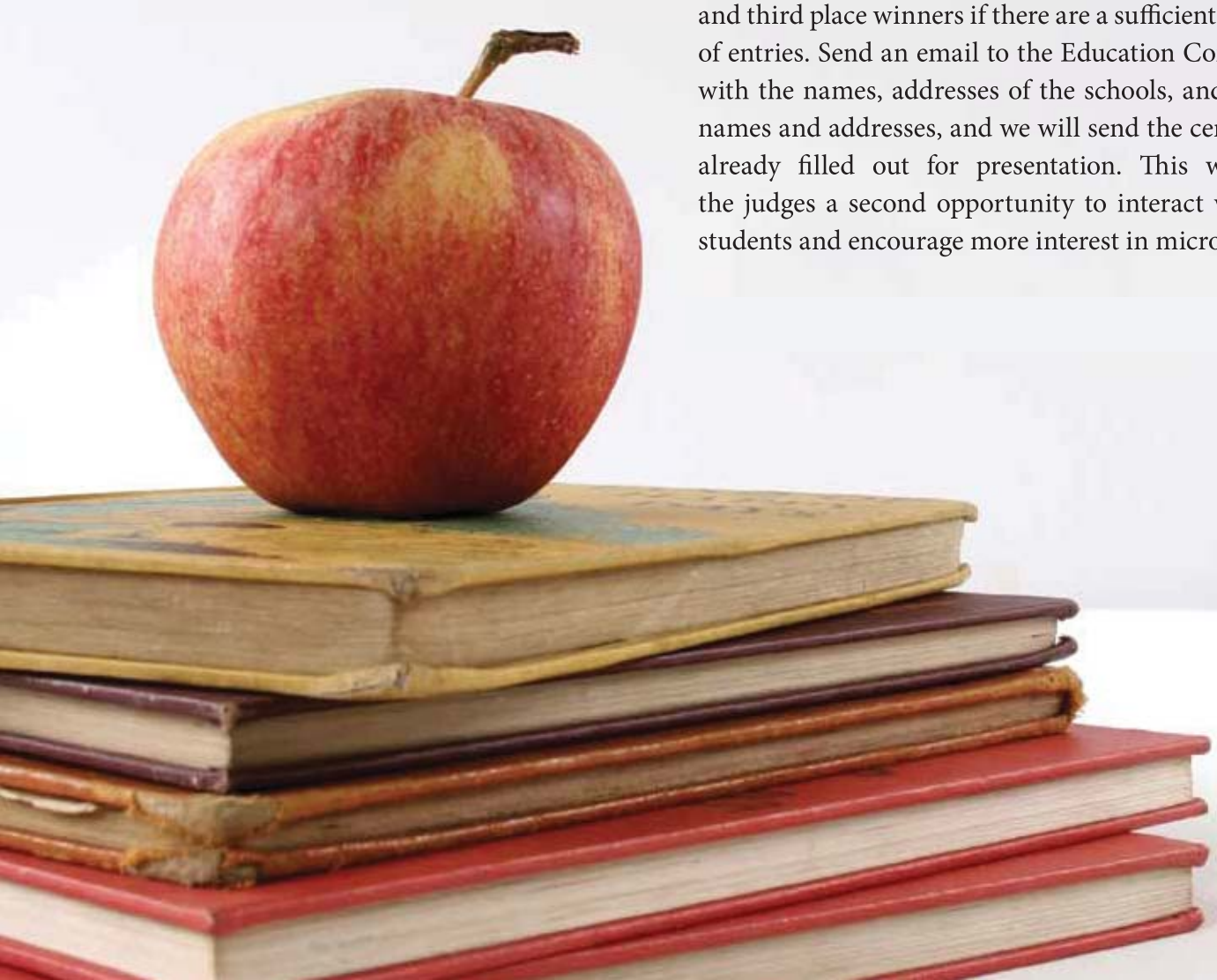
P: F:

Email:

Note: The default delivery method for publications is print, if no option is selected. If you DO NOT want a print copy mailed, select online access only.

Do You Judge Science Fairs?

Most science fairs have a section on microbiology and/or molecular biology, and many SIMB members assist local schools by judging in those categories. The SIMB Board of Directors authorized the Education Committee to provide certificates to be presented to students in science fairs. The criterion for receipt of a certificate is that a SIMB member must be judging in the fair. Certificates will be available to the first, second and third place winners if there are a sufficient number of entries. Send an email to the Education Committee with the names, addresses of the schools, and judges' names and addresses, and we will send the certificates already filled out for presentation. This will give the judges a second opportunity to interact with the students and encourage more interest in microbiology.



SIMB Booth 28

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We are shaking in anticipation!

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