STEM Society Meeting, July 12, 2016

James Emery

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1 About the STEM Society and the STEM Society Website

STEM is an abbreviation for Science, Technology, Engineering and Mathematics. The acronym STEM is commonly associated with K-12 education, but our use of the term is only slightly bound to this meaning. There are over one hundred people on the mailing list, although a much smaller group attends any one meeting. We meet on the second Tuesday of each month at the Trailside Center at 99th and Holmes in Kansas City, Missouri. The meetings are open to all. The start time is 6PM. We make presentations, have discussions, and have demonstration experiments. These relate to Science, the History of Science, Mathematics, Engineering, Philosophy and Technology at all levels. The topics have ranged from a technical discussion of the Mathematics of General Relativity to scientific experiments for young students.

These meeting notes contain links to many other documents, which may be viewed or downloaded by clicking the link. A partial list of documents can be reached by clicking the heading **Documents**. The meeting notes may also be viewed in an archive file (archive.pdf), which is in the list of documents. Many of the documents are PDF files. They may be viewed or downloaded to the computer by clicking, provided Adobe Reader, or another program capable of reading PDF files, is present. There are many more documents available at the site than are listed under **Documents** because the documents.htm file is not at all up to date. The last time I checked, about March 2014, there were about 350 document files on the site. We are in the process of creating better techniques for finding documents and authors. The first meeting of the STEM Society was in November of 2006. For several years we used the content management program called Joomla. It had a fancy looking interface, but was hard to use. It overran the space somehow at our internet provider Bluehost. So we now have a very simple HTML site. It is not so slick looking as Joomla, but is very easy to maintain and modify.

The web site is:

`http://www.stem2.org/`

Direct to the documents list:

`http://www.stem2.org/je/documents.htm`

Direct to the archive file:

`http://www.stem2.org/je/archive.pdf`

2 The July 12, 2016 Meeting Announcement

The July meeting of the STEM Society will take place on the second Tuesday of the month, July 12, 2016, at the Trailside Center at 99th and Holmes in Kansas City, Missouri. The starting time is 6PM. Also look at our website for past meeting notes:
The web site is:

`http://www.stem2.org/`

Possible Topics and Discussions:

(a) Some miscellaneous mathematics leading to Bezier Curves and orthogonal polynomial expansions.

(b) An introduction to using the Maple Symbolic computer program.

(c) Richard Rhodes wrote a book titled "Visions of Technology,". This could be a guide to a discussion of technology, what it is, and how it has developed.

(d) Things viewed at the recent Maker Faire, electronics, music et cetera.

(e) Book Reviews.

(f) The Johnson County Library Maker Space.

(g) As always, attendees are free to bring, and should bring additional topics, things, ideas, and presentations. We need more presentations from our very diverse and experienced fellowship.

3 James Emery: Some Mathematics

This document is called **Mathematical Miscellany**

http://www.stem2.org/je/misc.pdf

Contents.

- Mathematical Induction.
- The Binomial Theorem.
- Leibnitz Formula for the nth Derivative of a Product of Two Functions.
- Application to Legendre Polynomials.
- A List of Legendre Polynomials.
- Calculating Legendre Polynomials With Maple.
- Convex Sets and the Convex Hull.
- Applications of Legendre Polynomials and the Binomial Theorem.
- Application: Legendre Polynomials.
- Application: Bernstein Polynomials and Bezier Curves.
- Bibliography.

4 James Emery: Book Review, "Visions of Technology," by Richard Rhodes Editor, 1999

This is an anthology consisting of short pieces, from a paragraph to a few pages, about the history of technology from the beginning of the 20th century to almost the end. Rhodes the editor, contributed an introduction, with various comments throughout the book. There are about 220 contributions, making very interesting reading. Here are a few that I picked out:

- p32, Dec 12, 1901, St John's Newfoundland, Marconi hears pip-pip-pip, that was an "S"!
- p35, 1896, Henry Ford pictured in his first automobile.

- p39, Herbert Hoover crosses back to America from England. After very pleasant conversation with an English lady for several days, nearing New York, the lady asks, "May I ask, what is your occupation?" "Engineer" said Hoover. "Oh." said the Lady. "I thought you were a gentleman!"

- p54, Ellen Richards first female graduate of MIT, founded the Home Economics Movement, engineering in the home.

- p56, 1911, Samuel Gompers, labor leader, testifies before a house committee investigating "Taylorism."

- p59, 1914, H. G. Wells predicts an atomic bomb, from the 1909 book of Frederick Soddy, British Radiochemist.

- p61, Henry Ford "History is Bunk, only the present matters."

- p68 Margaret Sanger feminist calls for liberating women from "sex servitude," probably meaning liberation of women from the machine like baby production.

- p70 Election night November 2, 1920, first radio broadcast, station KDKA Pittsburgh.

- p71 Dangers of radio advertising.

- p73 1922, Author Karel Capek, coined the word "robot."

- p83 Alfred P Sloan, "Grind your bearings!"

- p102, 1931, Unlimited leisure.

- p106, 1930, The US Senate passes a resolution to replace the new difficult to use dial telephones, in favor of the previous human telephone operator system.

- p113, High speed flash photography with stroboscope of bullet piercing an apple, (Harold "doc" Edgerton of MIT, 1903-1990)

- p115 1933 Willis Gregg Energy From Air Conditioning. It was commonly thought that the low productivity of the south was due to the high temperatures in the south, contributing to lethargic workers, as

compared to the cooler more productive northerners. Gregg wrote that air conditioning would change this.

- p124, 1936, James Agee Overalls and productivity
- p139, 1939, E. B. White of the New Yorker, was not impressed with the world of tomorrow after touring the worlds fair, and made some sly remarks.
- p141, 1940, Otto Frisch and Rudolf Peierls: A Radioactive Super Bomb.
- p143, 1941 Buchenwald, technology applied to mass killing.
- p147, 1942 Plastics go to war.
- p151, 1944 Edwin Land Industrial Research
- p154, 1945 Advertising in the Radio age.
- p163, 1945 J. Robert Oppenheimer, The Problem With the Atomic Bomb
- p164, 1945 picture of the first atomic bomb, mass killing technology
- p173, 1945 DDT
- p178, George B. Dyson, first computer the ENIAC, U. Pennsylvania, programmed by plug boards.
- p185, 1948, the transistor
- p187, 1949 Murphy's Law
- p198, 1954 The Pill
- p209, 1959, C. P. Snow Natural Luddites
- p216, 1960, Norbert Wiener, Cybernetics, the art of steering
- p219, 1960, The first laser
- p227, 1961, Dwight D Eisenhower, the influence of experts
- p231, 1962, Rachel Carson, Silent Spring

- p235, 1963, Dr Strangelove, Stanly Kubrick and Terry Southern
- p240, Nov 9, 1965, Northeast Power Grid Failure, Loudon Wainwright
- p243, 1965, Gordon Moore, Moore's Law
- p359, 1995, Hans Bethe, A call on all scientists in all countries to cease and desist from work creating, developing, improving and manufacturing further nuclear weapons.

- p272, 1971, Square Rooting for Cal

  E to the X, dy! dx!
  Secant, cosine, tangent, sine
  Three-point-one-four-one-five-nine
  Square root, cube root, Q.E.D.,
  Slip stick! Slide rule!
  'ray U. C.!

5 James Emery: Book Review, "The Bourbaki Gambit," by Carl Djerassi, 1994

Carl Djerassi was an organic chemist (he died in 2015), who is famous for synthesizing the progesterone molecule, which made the birth control pill feasible. He also was a novelist and poet, (a bit of a C. P. Snow, "The Two Cultures." according to Bob Kessler, C. P. Snow gave a speech at the dedication of the Spencer Library at The University of Kansas, and also participated in the Cockafair lecture series at UMKC).

PCR, the polymerase chain reaction, is a method used in molecular biology to increase a single copy of DNA to multiple copies, generating up to millions of copies of a DNA sequence.

PCR was developed in 1983 by Kary Mullis while working for the CETUS corporation. He received the Noble Prize for this work in 1993. Mullis lived in Kansas City for a few years while associated with the Kansas University Medical Center. He used to hang out at Linda Hall Library. His book "Dancing Naked in the Mind Field" describes his invention experience. His children grew up in Kansas City and attended Pembroke Day school, after Mullis was divorced from their mother. He was a surfer and a bit of a hippie. A few years ago he gave a talk at Linda Hall Library, and I talked to him about his work and kids and so on. He said they were attending some Eastern Universities. I asked him if he was still surfing but he told me he had suffered a stroke and was no longer able to surf.

But back to the book. Nickolos Bourbaki is the author of many books on advanced mathematics. But a strange author because he does not exist. The books were written by a collection of French mathematicians, who published anonymously under the name Bourbaki.

The idea of the Bourbaki Gambit is for a group of older but distinguished Biochemists to get together and produce an outstanding scientific breakthrough under an anonymous female name. In this fictional account their breakthrough was the invention of PCR. There is sex and a lot of socializing supposedly showing how scientist really live. There is a description of PCR and various things of interest, but I can't say that I really enjoyed reading it, or got much out of it.

6 Future Talk on Thermodynamics

Jim,

Ken Schmitz, a physical chemist recently retired from UMKC, is working on a PC textbook in which he takes a theoretically and pedagogical interesting and novel approach to the treatment of energy, thermodynamics, etc. If you think the topic would be of interest and we have an open date, I'll ask him to come and talk to us. Ken is a lucid and engaging speaker.

In case you would prefer to contact him directly, Ken's email; is

SchmitzKS@umkc.edu¿

Greg Hodes 816-361-9968

7 James Emery: Kansas City Maker Faire 2016

The Faire was as big as ever, but I did not see the people I know that started the Faire. There might be a high burn out rate.

However, there are plenty of replacements, a lot of young people, high school and college students.

There was much to see and I did not see a whole lot.

There was an IEEE table, young guys, and at least one older guy there who has Parkinson's disease and insisted that I feel the bumps on his head where he has some kind of implants that have eliminated his shaking.

At another table there was an electronics engineer who was selling some add on boards for the Raspberry PI. He said he has worked everywhere for electronics companies, in Silicon Valley I suppose, including Hewlett-Packard.

On the website pi-plates.com, he says that he has experienced unexpected demand, and is out of some of the boards, but they will in stock by the 16th

of July. He designed the boards and had them manufactured in China.

I was serenaded by a SteamPunk band outside in the unbearable heat. They were all classically trained musicians.

8 James Emery: The Johnson County Maker Space

This space is still going strong. The laser cutter is the most popular. I tried it out a while back. It is controlled by a laptop running Corel Draw (Bezier curves!). There is always someone there to help. There are several 3-d printers. To use the machines at the space, you only have to reserve time at the website. No library card is even needed, and some material is supplied by by the library, including the plastic for the 3-d printers. The space is sponsored by Black and Veatch who apparently purchased some of the equipment.

9 Rich Kaufman: CRISPR

We did not talk about this subject at the meeting.
From: Rich Kaufman richkaufmanpv@hotmail.com Jul 8 at 12:48 PM
To: jim emery
Although I don't know any details, the popular press is full of raves about a technique for gene deletion called CRISPR.

CRISPR: Clustered Regularly Interspaced Short Palindromic Repeats CRISPR is pronounced crisper, these are segments of prokaryotic DNA containing short repetitions of base sequences. Each repetition is followed by short segments of "spacer DNA" from previous exposures to a bacteriophage virus or plasmid

A man a plan a canal Panama. is a famous palindrom, with the set of the first letter of the words, reading the same when the words are written in the reverse order.

See the Wikipedia article on **CRISPR**.

Glossary
prokaryotic - not having a cell nucleus, (before a nucleus)
eukaryotic - having a true cell nucleus

plasmid - A string of DNA having a ring structure with the beginning joining the end.
The Cas9 enzyme:
From the internet:
Brian Farley, Molecular and Cell Biology Postdoc, UC Berkeley:

"In its natural context, CRISPR (named for the clustered regularly spaced short palindromic repeats that I'll discuss in a bit) is at the core of a rudimentary bacterial immune system. One of the biggest threats to bacteria is DNA from external sources – like viruses, for example. To be able to guard against this threat, bacteria need to be able to identify DNA that isn't theirs and somehow destroy it.

This is where the literal CRISPR sequences get involved. Most bacteria contain one or a few arrays of CRISPR sequences in their genomes. These are typified by repeats of a short sequence that are separated by spacer sequences. Each spacer corresponds to a fragment of foreign DNA that the bacterial lineage has previously encountered and survived. The entire CRISPR array is transcribed into RNA and processed into short pieces (by cutting the long RNA molecule at each of the repeated sequences), which are then loaded into an enzyme that's capable of cutting DNA.

The short RNAs (called guide RNAs) grant specificity to the enzyme molecules to which they're bound. Because the guide RNAs are derived from known foreign sequences, they're essentially a pool of all known DNA-based threats to the cell; should any of those DNA molecules enter the cell again, they'll be specifically identified and destroyed.

There are many different systems of enzymes that different bacterial species use to process and load guide RNAs and use the protein-RNA complexes to cut DNA, but the simplest by far is exemplified by the CRISPR system of Streptococcus pyogenes. Identification and cleavage of foreign DNA is handled by just one enzyme: Cas9. Furthermore, Cas9 can be loaded with RNAs without the aid of any other proteins – meaning that if Cas9 is presented with an RNA of an appropriate size and shape, it will load itself. In other words: Cas9 is a programmable DNA endonuclease.

Because the genetic code is nearly universal, a protein coding sequence from bacteria can be relatively easily engineered to code the same protein in all other species. So, we can make cells from almost any species express Cas9 and we can program it with nearly any sequence we'd like – in other words, Cas9 enables us to cut almost any sequence in almost any genome we want.

Double-stranded breaks in DNA are universally intolerable across all

species, and life has evolved multiple ways to quickly identify and repair them, should they arise. One of these is called non-homologous end joining. It essentially takes the two broken ends and forces them back together again, and it is very error prone. So, if we program Cas9 to cut inside of a gene, and that cut is repaired by NHEJ, the gene will be mutated and likely rendered non-functional: we can mutate genes.

Another repair pathway is called homologous recombination. Most cells carry two nearly identical copies of their genome; if one copy gets broken, the cell can use the other to make a near perfect repair by HR. We can use Cas9 and HR together to change sequences and insert entirely new sequences into the genome. If we supply a DNA repair template that looks like the edit we'd like to make along with Cas9, some cells will use it to repair the double-stranded break instead of the other "normal" copy of the genome. If we make two nearby cuts in the genome, we can replace entire sequences with whatever we'd like, provided that we can synthesize the DNA. So: we can edit genomes.

This is incredibly powerful, because it allows us to make almost any small change to almost any genome we'd like. We can use patient derived stem cells to engineer healthy cells, tissues, and organs and reintroduce them into the patient, minus whatever mutations they may have had previously. We can alter crops to have higher yields with lower inputs. We can potentially sterilize entire populations of pest species, thereby engineering entire ecosystems. Cas9 makes genomes plastic, and gives us a tremendous ability to bend nature to our will.

Cas9 also opens up a lot of new research avenues, as it allows us to make incredibly fine-grained alterations to research specimens and ask what they do. We can even engineer variants of Cas9 that don't cut DNA at all, but instead recruit factors that turn genes on – allowing us to ask not only what happens when there's too little of a gene being expressed, but also too much.

Cas9 is already having a profound effect on both research and engineering, and we're only just getting started. Updated 8 Jun 2015 "
In 2007, Barrangou, Horvath, and other food industry scientists at Danisco provided the first experimental evidence that CRISPR was an adaptive immune system.

Clustered DNA repeats with short unique sequences between the repeat units were first described in the bacterium Escherichia coli by Osaka University researcher Yoshizumi Ishino in 1987.

A Molecular Biology Glossery from the University of Michigan

A Molecular Biology Glossary

A Quick and Dirty Reference to Terms Used in Molecular Biology

Dr. Robert H. Lyons, Director
University of Michigan DNA Sequencing Core

This document is intended to provide a quick reference for molecular biology terms. It does not go into depth on the terms, but can be useful if you are trying to understand a typical seminar or paper. For further information on any of these topics, please consult one of the standard cell and molecular biology textbooks (for example, "Molecular Biology of the Cell" by Alberts et al., 4th ed., Garland Science, New York NY, ISBN 0-8153-3218-1).

July 2, 1998

https://seqcore.brcf.med.umich.edu/sites/default/files/html/educ/dnapr/mbglossary/mbgloss.html

Avi Flamholz, they tell me I am a PhD candidate. still skeptical

2.9k Views "There is a ton to say about Cas9, but I am going to keep this answer shortish because a lot of ink has already been spilled on this topic (references below) and because Wikipedia coverage of the CRISPR systems is adequate (CRISPR). UPDATE: Wikipedia now has an excellent page on Cas9 itself.

Cas9 stands for "CRISPR associated protein 9" meaning that it is a protein that is associated with the CRISPR bacterial immunity system (see Wikipedia link above). In short, the CRISPR system involves a number of bacterial proteins that identify viral DNA, cut it up and store a chunk inside the bacterium's genome as a record for future use. When the bacteria is next infected by a related virus (i.e. one with similar DNA) it can use this record to notice the infection before it gets out of hand, which it does by identifying and cutting up that DNA using Cas9 and proteins related to it.

Cas9 is an RNA-guided DNA nuclease enzyme found in S. pyogenes (a bacterium). What that means is that (1) Cas9 can cut DNA and (2) Cas9 finds the DNA that it cuts by comparing it to an RNA "guide" molecule. If the RNA guide sequence is complementary to a particular piece of DNA, Cas9 will cut the DNA thereby making a double strand break.

So what's the big deal? For reasons that you can read about on Wikipedia (Homologous recombination and Non-homologous end joining), cutting DNA

at a specific location enables you to edit DNA at that location. So you can use Cas9 and a chosen guide RNA to remove specific genes from organisms, add new genes to them in specific places, edit existing genes, etc. Historically, this kind of "genome editing" has been doable in certain bacteria and fungi but very very very challenging for researchers working with plants, animals or even slightly more esoteric microbes than E. coli. What's more, Cas9 seems to work really well in a lot of different organisms, including many bacteria, yeasts, plants, algae and human cells (Big Deal #1, see references). To further sweeten the deal, you can disable the nuclease domains (the parts that do the cutting) and direct Cas9 to "sit" on particular DNA sequences near genes, which has been shown to repress expression of those genes (i.e. prevent them from turning into RNA and then protein, see the Central dogma of molecular biology). This enables researchers to dissect genomes with incredible precision, even in organisms that had previously been quite intractable (Big Deal #2).

In short, Cas9 seems to be the genetic engineering silver bullet that biologists in many fields have been waiting generations for (to paraphrase myself). The discovery of Cas9 makes it possible to genetically engineer pretty much any organism on the cheap, which has already opened a whole ton of doors for research and biotechnology."

References

Jinek, M., Chylinski, K., Fonfara, I., Hauer, M., Doudna, J. a, and Charpentier, E. (2012). A programmable dual-RNA-guided DNA endonuclease in adaptive bacterial immunity. Science (New York, N.Y.), 337(6096), 81621. doi:10.1126/science.1225829

Mali, P., Esvelt, K. M., and Church, G. M. (2013). Cas9 as a versatile tool for engineering biology. Nature methods, 10(10), 95763. doi:10.1038/nmeth.2649

Belhaj, K., Chaparro-Garcia, A., Kamoun, S., and Nekrasov, V. (2013). Plant genome editing made easy: targeted mutagenesis in model and crop plants using the CRISPR/Cas system. Plant methods, 9(1), 39. doi:10.1186/1746-4811-9-39

Gilbert, L. a, Larson, M. H., Morsut, L., Liu, Z., Brar, G. a, Torres, S. E., Qi, L. S. (2013). CRISPR-mediated modular RNA-guided regulation of transcription in eukaryotes. Cell, 154(2), 44251. doi:10.1016/j.cell.2013.06.044"

10 Tom Grant: The Vanishing of the Anasazi Indians

The Anasazi indians are known as the ancient people and are given credit for the origination of the cliff pueblos of the southwest. Their creation myth says that they came from "a hole in the ground." The Anasazi were the ancestral Puebloans of the "Four Corners" region of the United States, consisting of the region surrounding the place where the states of Utah, Arizona, New Mexico, and Colorado meet in a point. "pueblo" means village in Spanish. The Mesa Verde national park is an area where they lived. They lived in pit houses that offered them great protection from small groups of invaders. But neighboring Puebloans disliked them and considered them witches for their great knowledge, thought to be witchcraft at its source, such as their ability to protect the ground, to keep it somewhat moist, and thus to grow abundant crops in this very dry area in the southwest. Being witches, the neighbors decided to destroy them, so they put their "pit houses" under seige, and although these houses were quite secure from small groups of attackers, they succombed to the large siege, and the Anasazi were all destroyed.

This is a theory that Tom perhaps may have constructed or embelished himself, but I am not sure that he is really claiming this. He is scheduled to deliver a talk about this to an expert group later, I think, and said he wanted to talk to us about it, as preparation for this later talk.

11 John Gamble, Theta Functions

John Gamble informed me at the meeting, that he wanted to talk about theta functions. However, the meeting had gone on for quite some time, and people were ready to go home.

John told me that he learned about theta functions from Rainville's book titled **Special Functions.**

He said he read the chapter on theta functions in the bathtub. This seems a bit dangerous, if not for John, certainly for the book. Maybe we can hear more about this at a later meeting.

12 References

[1] Alberts Bruce, et al, **Molecular Biology of the Cell**, 6th ed., 2014, Garland Science, New York NY.

[2] Rainville Earl D, **Special Functions**, Chelsea Publishing Company, 1960.