CIMNE EXCELENCIA SEVERO OCHOA

WINTER SCHOOL

An excursion into computational methods

January 24th – 28th, 2022

Poster

Narges Dialami

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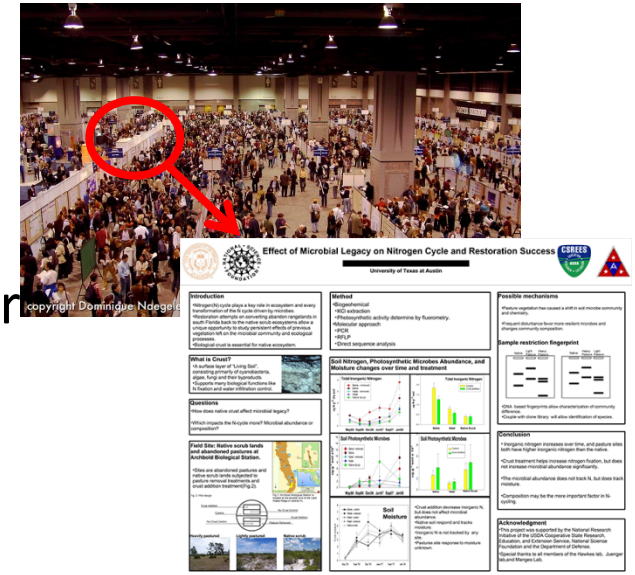
What is a research poster?

- Posters are widely used in the academic community
- Most conferences include poster presentations in their program.
- Research posters **summarize** information on research **concisely** and **attractively** to help publicize it and generate discussion.
- The poster is usually a mixture of a **brief text mixed** with **tables, graphs, pictures,** and other presentation formats.
- At a conference, the researcher stands by the poster display while other participants can come and view the presentation and interact with the author.



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To prepare a good poster…

You need to merge all the knowledge and experience you have in preparing both oral presentations and written reports

With posters we are going a step further….

Likewise ORAL PRESENTATIONS

- Need to **grab the attention** in a very short time (and space)
- **Visual aid**
- «Extreme» **summary** of your research

Likewise WRITTEN PAPERS

- **Structure** similar to a research paper
- High **accuracy** (references, citations, ….)
- **Static**
- **Text based** with the inclusion of images

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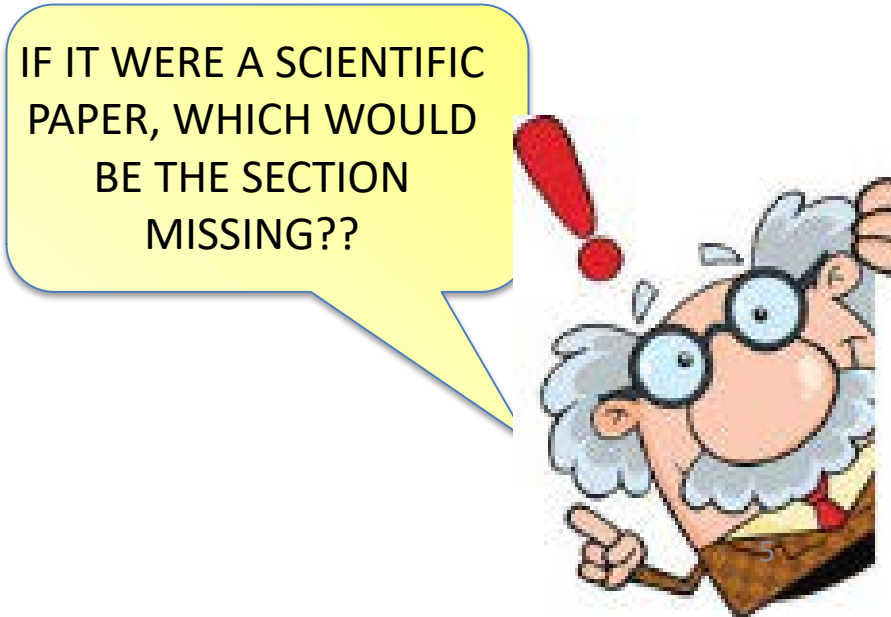
SCIENTIFIC CONTENT

SECTIONS OF YOUR POSTERS

- Introduction
- Objectives
- Methodology
- Results
- Conclusions
- Acknowledgements
- References



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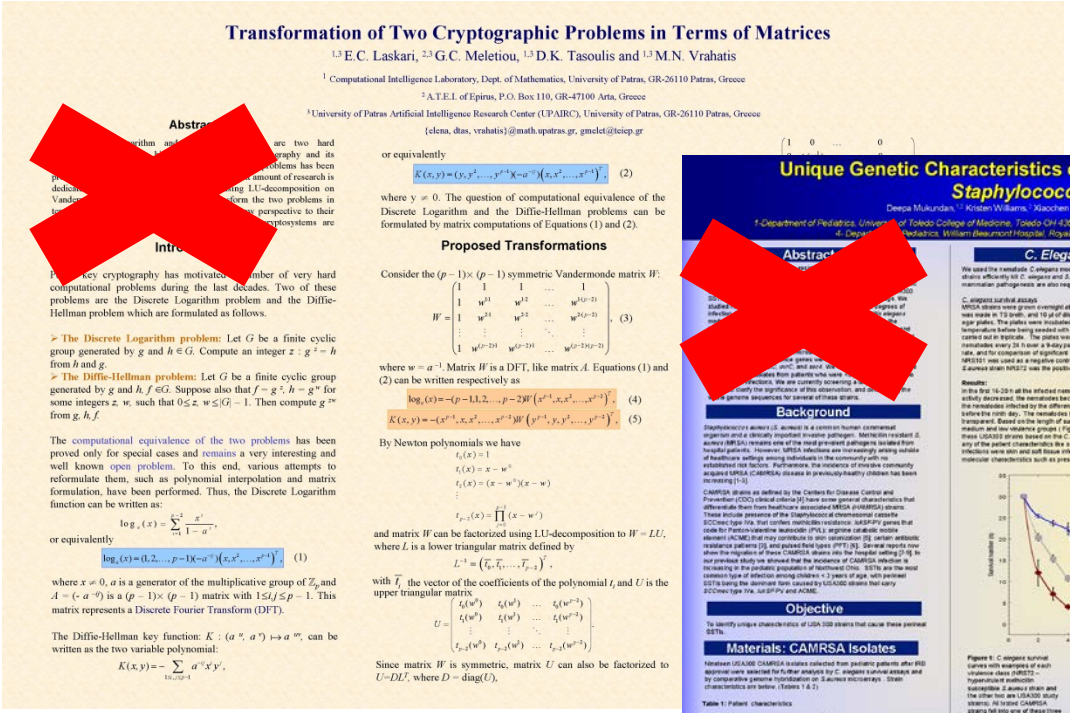
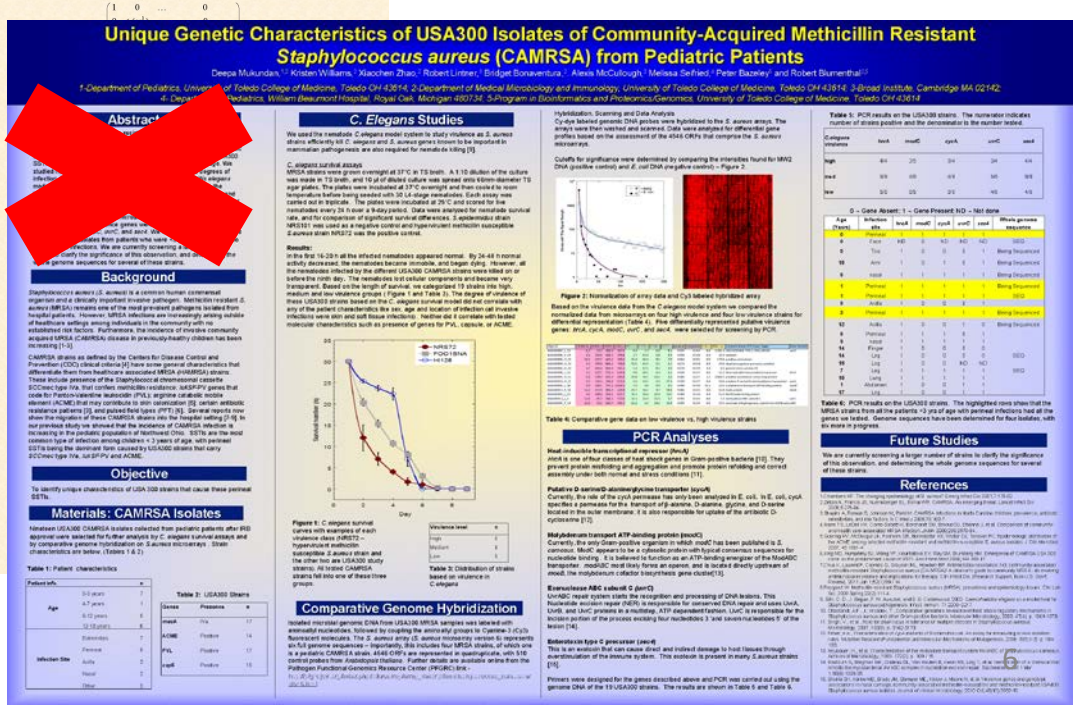
SECTIONS OF YOUR POSTERS

NO ABSTRACT

Do not include an abstract on a poster.

A poster *is* an abstract of your research





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SECTIONS OF YOUR POSTERS

"A poster *is* an abstract of your research"

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TECHNICAL ASPECTS

Tools and Layout

Choose your tool

- Power point

(Free (with Office), a lot of templates, a lot of tutorials)

- Adobe Photoshop
- Adobe Illustrator

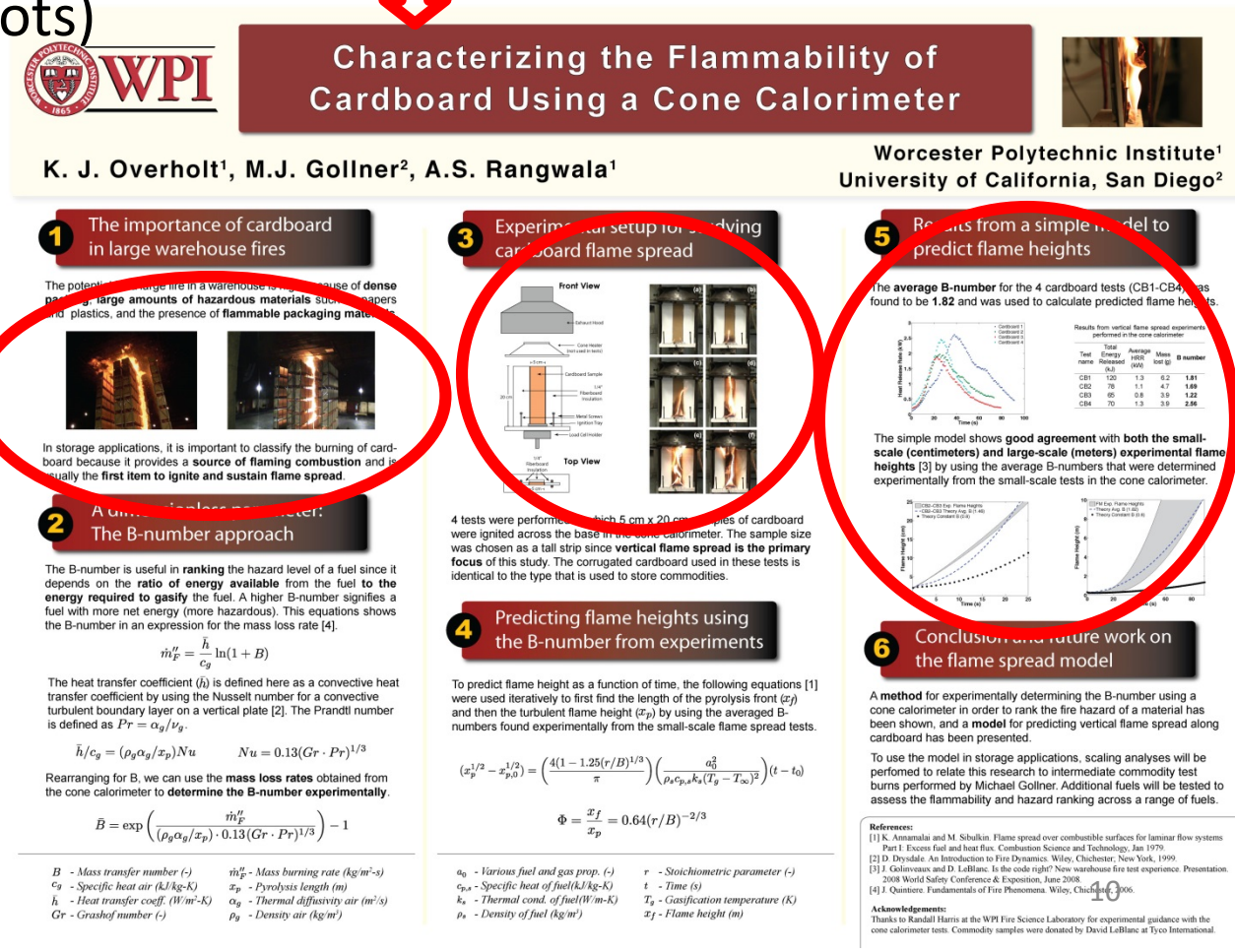
Very expensive, suitable for graphic artists

- Latex (http://www.brian-amberg.de/uni/poster/ http://www.latextemplates.com/template/jacobs-landscape-poster)

Remember that…

You must attract an audience:

- Prominent title
- Attractive figures (lots)
- Clean, open layout



WPI

Characterizing the Flammability of Cardboard Using a Cone Calorimeter

K. J. Overholt[1], M.J. Gollner[2], A.S. Rangwala[1]

Worcester Polytechnic Institute[1]
University of California, San Diego[2]

1 The importance of cardboard in large warehouse fires

The potenti[illegible] large fire in a warehouse is [illegible] because of **dense pa[illegible]g, large amounts of hazardous materials** such [illegible] papers and plastics, and the presence of **flammable packaging mate[illegible]**

In storage applications, it is important to classify the burning of cardboard because it provides a **source of flaming combustion** and is usually the **first item to ignite and sustain flame spread**.

2 A dim[illegible]less pa[illegible]eter: The B-number approach

The B-number is useful in **ranking** the hazard level of a fuel since it depends on the **ratio of energy available** from the fuel **to the energy required to gasify** the fuel. A higher B-number signifies a fuel with more net energy (more hazardous). This equations shows the B-number in an expression for the mass loss rate [4].

$$\dot{m}''_F = \frac{\bar{h}}{c_g}\ln(1+B)$$

The heat transfer coefficient ($\bar{h}$) is defined here as a convective heat transfer coefficient by using the Nusselt number for a convective turbulent boundary layer on a vertical plate [2]. The Prandtl number is defined as $Pr = \alpha_g/\nu_g$.

$$\bar{h}/c_g = (\rho_g\alpha_g/x_p)Nu \qquad Nu = 0.13(Gr\cdot Pr)^{1/3}$$

Rearranging for B, we can use the **mass loss rates** obtained from the cone calorimeter to **determine the B-number experimentally**.

$$\bar{B} = \exp\left(\frac{\dot{m}''_F}{(\rho_g\alpha_g/x_p)\cdot 0.13(Gr\cdot Pr)^{1/3}}\right) - 1$$

B - *Mass transfer number (-)*
c_g - *Specific heat air (kJ/kg-K)*
$\bar{h}$ - *Heat transfer coeff. (W/m²-K)*
Gr - *Grashof number (-)*
$\dot{m}''_F$ - *Mass burning rate (kg/m²-s)*
x_p - *Pyrolysis length (m)*
α_g - *Thermal diffusivity air (m²/s)*
ρ_g - *Density air (kg/m³)*

3 Experim[illegible]tal setup for [illegible]dying cardboard flame spread

Front View

Top View

4 tests were performe[illegible] which 5 cm x 20 cm [illegible]ples of cardboard were ignited across the base in the cone calorimeter. The sample size was chosen as a tall strip since **vertical flame spread is the primary focus** of this study. The corrugated cardboard used in these tests is identical to the type that is used to store commodities.

4 Predicting flame heights using the B-number from experiments

To predict flame height as a function of time, the following equations [1] were used iteratively to first find the length of the pyrolysis front (x_f) and then the turbulent flame height (x_p) by using the averaged B-numbers found experimentally from the small-scale flame spread tests.

$$(x_p^{1/2} - x_{p,0}^{1/2}) = \left(\frac{4(1-1.25(r/B)^{1/3}}{\pi}\right)\left(\frac{a_0^2}{\rho_s c_{p,s} k_s (T_g - T_\infty)^2}\right)(t-t_0)$$

$$\Phi = \frac{x_f}{x_p} = 0.64(r/B)^{-2/3}$$

a_0 - *Various fuel and gas prop. (-)*
$c_{p,s}$ - *Specific heat of fuel(kJ/kg-K)*
k_s - *Thermal cond. of fuel(W/m-K)*
ρ_s - *Density of fuel (kg/m³)*
r - *Stoichiometric parameter (-)*
t - *Time (s)*
T_g - *Gasification temperature (K)*
x_f - *Flame height (m)*

5 Re[illegible]ts from a simple m[illegible]del to predict flame heights

The **average B-number** for the 4 cardboard tests (CB1-CB4) [illegible]as found to be **1.82** and was used to calculate predicted flame hei[illegible]ts.

Results from vertical flame spread experiments performed in the cone calorimeter

Test name	Total Energy Released (kJ)	Average HRR (kW)	Mass lost (g)	B number
CB1	120	1.3	6.2	**1.81**
CB2	78	1.1	4.7	**1.69**
CB3	65	0.8	3.9	**1.22**
CB4	70	1.3	3.9	**2.56**

The simple model shows **good agreement** with **both the small-scale (centimeters) and large-scale (meters) experimental flame heights** [3] by using the average B-numbers that were determined experimentally from the small-scale tests in the cone calorimeter.

6 Conclusi[illegible] and future work on the flame spread model

A **method** for experimentally determining the B-number using a cone calorimeter in order to rank the fire hazard of a material has been shown, and a **model** for predicting vertical flame spread along cardboard has been presented.

To use the model in storage applications, scaling analyses will be perfomed to relate this research to intermediate commodity test burns performed by Michael Gollner. Additional fuels will be tested to assess the flammability and hazard ranking across a range of fuels.

References:
[1] K. Annamalai and M. Sibulkin. Flame spread over combustible surfaces for laminar flow systems Part I: Excess fuel and heat flux. Combustion Science and Technology, Jan 1979.
[2] D. Drysdale. An Introduction to Fire Dynamics. Wiley, Chichester, New York, 1999.
[3] J. Golinveaux and D. LeBlanc. Is the code right? New warehouse fire test experience. Presentation. 2008 World Safety Conference & Exposition, June 2008.
[4] J. Quintiere. Fundamentals of Fire Phenomena. Wiley, Chichester, 2006.

Acknowledgements:
Thanks to Randall Harris at the WPI Fire Science Laboratory for experimental guidance with the cone calorimeter tests. Commodity samples were donated by David LeBlanc at Tyco International.

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Galaxy Zoo: an Experiment in Public Science Participation

December 22nd · December 23rd · December 28th · December 29th · December 30th · January 1st · January 3rd · January 5th

Rationale

Many interesting questions about galaxies are questions about morphology. What determines whether a galaxy is spiral or elliptical? How is morphology controlled by a galaxy's formation and evolutionary history? What role does environment play? How do all these factors change with redshift?

To answer these questions, we must have a sample of galaxies classified by shape. This is a very difficult problem for computers to handle, so classification must be done by eye. Kevin Schawinski, then a graduate student at Oxford, di… this to classify 50,000 galaxies from the Sloan Digital Sky Survey. However … classify the entire SDSS spectroscopic sample of galaxies would have ta… Kevin - or even a team of astronomers - far too long to be practical.

To solve this problem, we turned to citizen scientists - the millio… around the world not employed as professional scientists who … desire to contribute to science. Inspired by successful projects lik… Stardust@Home, we set up the Galaxy Zoo website.

The Site

The Galaxy Zoo home page is shown to the right. Volunteers log in to the site and read a short tutorial on how to classify galaxies. Then, they must pass a test of their skill in classifying galaxies of known types. Once they pass the trial, their classifications are included in the final dataset.

Volunteers use the Galaxy Analysis interface (right) to classify galaxies. They are shown one galaxy at a time from the Sloan Digital Sky Survey's spectroscopic galaxy sample. They click one button to classify the galaxy as:

- -elliptical
- -spiral (clockwise/counter/edge-on)
- -star
- -merger

Screenshots of the G… homepage (top) an… Analysis page (b…

Once a user has classified a galaxy, the site immediately shows the next galaxy. Several of our volunteers have said that it is this feature that kee… they feel like they want to do just "one more galaxy."

Volunteers

We thought that if we got 10,000 volunteers within the first month, we could declare the project a success. We launched the site on Sunday, July 8th, 2007. The next day, we got a segment on Galaxy Zoo onto the BBC morning radio programme. Soon after, the Associated Press wrote a story, and several blogs commented on the story. A post about Galaxy Zoo appeared on Slashdot.

Thanks to this media coverage, we had an immediate flood of volunteers, crashing our web server, which we frantically fixed. By the end of the first day, 22,000 volunteers had done nearly 500,000 classifications.

Since then, we have continued to attract new volunteers at a steady rate. We currently have 125,000 volunteers, who have done more than 40 million classifications.

Each galaxy has been classified an average of more than 30 times. These repeat classifications, along with Kevin's original classifications, give us ways to investigate the reliability and validity of our volunteer classifications. Chris will say more about this in his talk on Friday at 10 AM in Ballroom E, "Preliminary Results from Galaxy Zoo: the Sloan by Eye."

We are very interested in learning why our volunteers have participated so enthusiastically - what are they getting out of the site? We have some ideas, but we want to study this question systematically. See the "Social Science Research" section of the poster for more on this question.

Volunteer Support

By the end of the first week, we had more than 10,000 E-mails in our Inbox, many of which were people pointing out beautiful or interesting objects that they had come across. It became clear to us that we needed a way for volunteers to help each other. Phil Murray created a forum, www.galaxyzooforum.org . The staff working on the site moderate the forum - we were quickly nicknamed "zookeepers" by the volunteers who use the forum. W… as modera… encoura…

No… E…

M. Jordan Raddick[1] (raddick@pha.jhu.edu), Chris Lintott[2], Kevin Schawinski[2], Daniel Thomas[3], Robert Nichol[3], Dan Andreescu[4], Steven Bamford[3], Kate Land[2], Phil Murray[5], Anze Slosar[6], Alex Szalay[1], Jan Vandenberg[1], The Galaxy Zoo Volunteers

[1]Department of Physics and Astronomy, Johns Hopkins University, 3701 San Martin Dr., Baltimore, MD 212… (410) 516-8889

[2]Oxf… ity, 3University of Portsmouth, 4Freelance, 5Fingerprint Di… 6University of … rkeley

ABSTRACT

… modern astrophysics research is the re… …nd its history. Research into this q… …hers must first assign a shap… …a computer, but easy fo… …d take an enormou… …turned to citi… …ites the … fro…

The Galaxy Zoo blog

To show how sc… Zoo, we have start… science team posts t… Thursday (a different pe… the research he or she is doing … classification data. They write abou… y are doing and why. On Monday, Kevin po… about his work finding blue elliptical galaxies in the Galaxy Zoo dataset. Next week, Kate Land will post about her research into rotation directions of galaxies and its implications for cosmology.

Future Plans

We are working with international teams to translate the site into other languages, to allow more people to join the volunteer effort. Lech Mankiewicz of the Center for Theoretical Physics in Warsaw led a team to create a Polish version of the site. We are also exploring French and Chinese translations.

We are also designing plans for "Galaxy Zoo 2.0," which will include more detailed classifications. We have such an incredible community of citizen scientists, and we don't want to lose them because we ran out of things to do! Galaxy Zoo 2.0 will last at least several months, but we are looking for ideas for what to do after that.

We have also requested time on a number of telescopes to follow up on interesting objects that our volunteers have found. The one that has received the most discussion on the forums has been "Hanny's Voorwerp," a mysterious blue blob discovered by a teacher from the Netherlands ("voorwerp" is Dutch for "object").

"Hanny's Voorwerp"

Social Science Research

We have been amazed at the dedication of volunteers, some of whom spend an hour a day classifying galaxies. What are they getting out of it? We have talked about this with people on the forum, and have gotten several answers: a desire to aid scientific research, appreciation of the beautiful galaxy images, and enjoyment of the "game" nature of the site.

The question of motivation to participate in citizen science has received little attention in social science literature, although other technical volunteer efforts like Wikipedia and open source software have been studied. Knowing more about volunteer motivation can help our community better design citizen science projects in the future, as well as making a contribution to the field of motivation studies in general.

We plan to conduct a series of interviews with randomly-chosen volunteers to probe their self-reported motivations. Then, we will conduct a survey, reaching as many volunteers as possible. We will ask users to optionally report their site usernames so we can anonymously track their classifications. Can we find a correlation between their self-reported motivation and the amount of time they spend per galaxy, for example?

…re nearly ready to apply to Human Subjects review boards for permis… …egin the study. We are actively seeking education research partners … with us on this study.

Lessons for Citizen Science

Working on this project the last six months has taught us many lessons about how to do a successful citizen science project. Here are a few such lessons.

1) Beware of success: We were unprepared for the massive interest that our announcement generated. It was only the quick thinking of our IT support staff at Johns Hopkins that saved us from further down time when the web server crashed. This applies also to E-mail support. Although we now give at least a short reply to every E-mail we receive, we still have not caught up on our 10,000 back E-mails.

2) Reward participation, not competition: We initially listed the usernames of the people with the highest number of galaxies, but this led to unhealthy competition among some users, including attempts to cheat. We were able to weed out the cheaters, but it caused us annoyances. Rewarding participation from all users creates a sense of community spirit that makes more people want to participate.

3) Show volunteers what you do with their data: One of the most common questions on the forum is requests for updates on the status of our …earch - people want to know what we're doing with their results. We have …pted to satisfy this interest through the blog.

…vide a sense of satisfaction: We found that when we immediately …played the next galaxy after one classification, it provided a sense of satisfaction for the volunteer. They had done one galaxy successfully, and we trusted them to move on to the next one.

5) Treat volunteers as collaborators: What volunteers really want is to be thought of as scientific colleagues. It's important to take them and their contributions seriously when answering their questions. We are creating a web page listing Galaxy Zoo volunteers by name (for those who have chosen to participate), and we plan to link to this page from any journal articles we write.

Thank You!

All galaxy images used in Galaxy Zoo come from the Sloan Digital Sky Survey. Funding for the SDSS and SDSS-II has been provided by the Alfred P. Sloan Foundation, the Participating Institutions, the National Science Foundation, the U.S. Department of Energy, the National Aeronautics and Space Administration, the Japanese Monbukagakusho, the Max Planck Society, and the Higher Education Funding Council for England.

We wish to thank our colleagues, the 125,000 volunteer scientists of Galaxy Zoo, who include:

Jason Lane, Siegi Rogers, Johannes Gerk, Chanda Taylor, Wayne T Beck, Albert Tennant, Gray Ward, Aldo Ienna, Alice Sheppard, P. C. Byron, Elaine Randall, Alan Copland, Alessandro Levati

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Which size? Orientation?

- The conferences usually suggest a format for the posters
- Remember to set up your power point page before starting your poster (unless you are using templates)

- Choose your poster orientation:

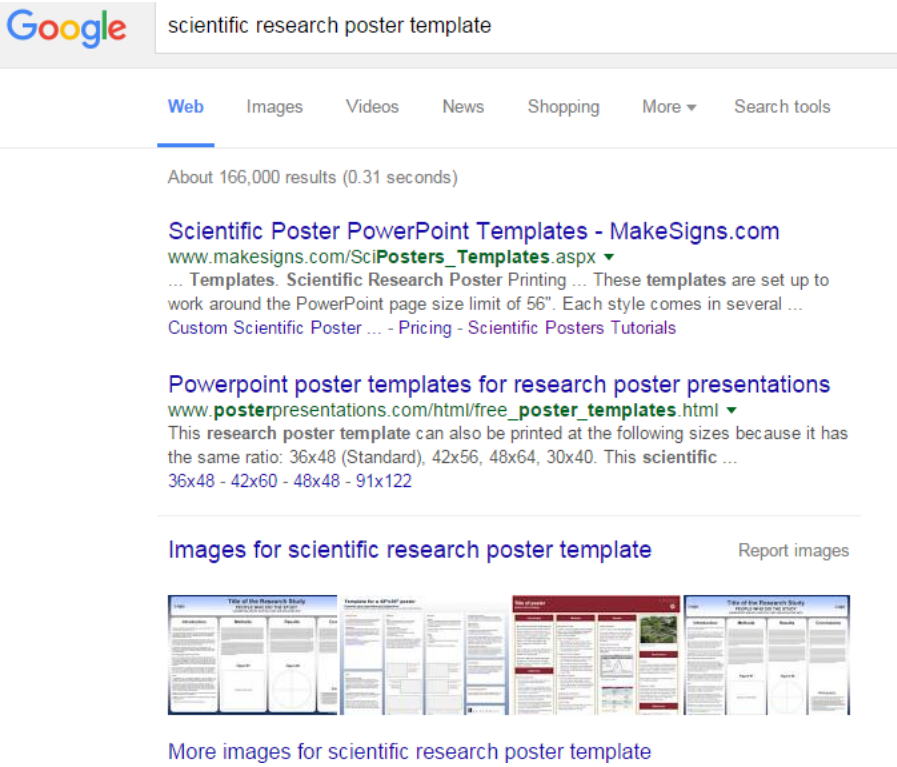
TEMPLATE or blank page?

A huge number of templates is available.

Just google it!

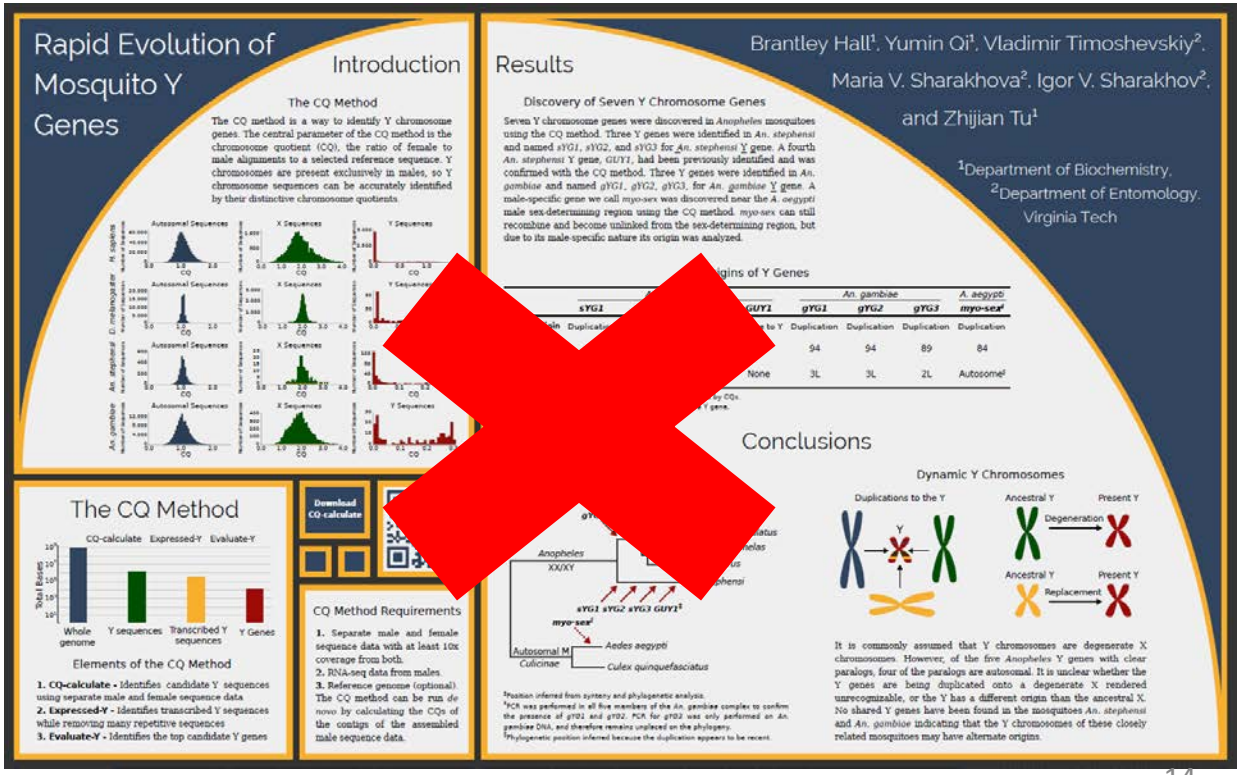
Useful link:

[Pimp my poster](#) blog where people upload their poster and get suggestions and comments



Flow of poster

- Keep it simple
- Keep it ordered



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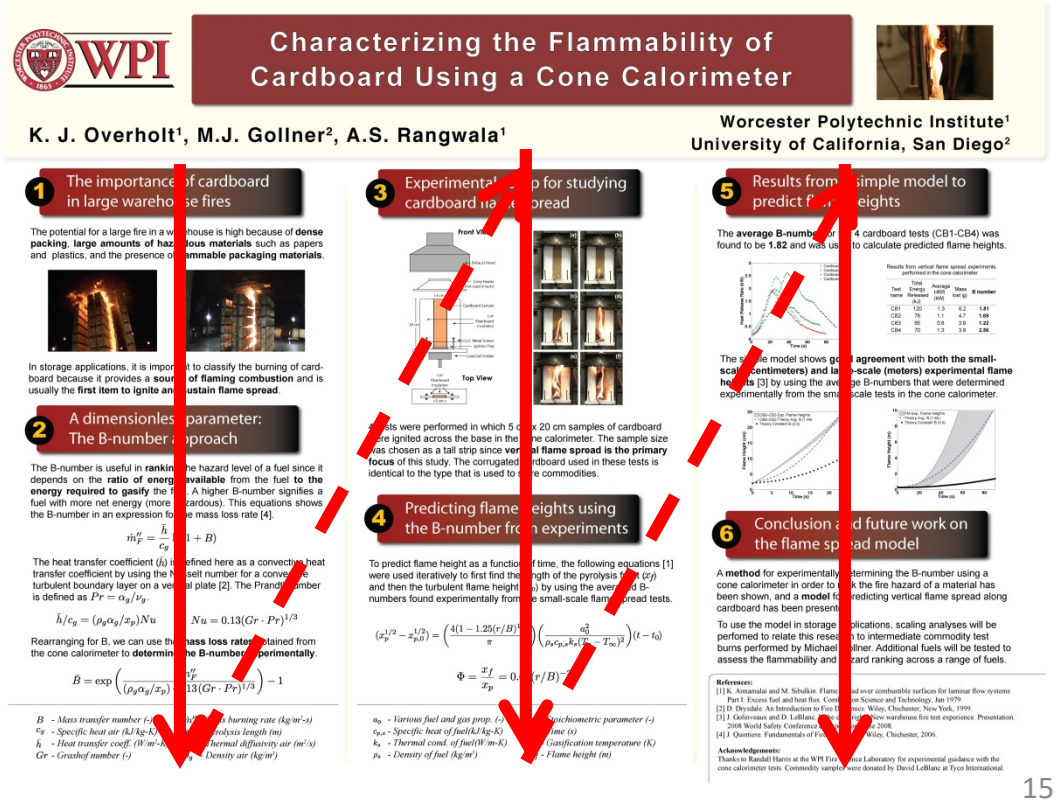


Background

Background color

Background color

Background

Dark Background color (TITLES)

Fair Background color (TEXT)

Use contrasting colors between the text and the background

Similar colors for foreground background

FONTS

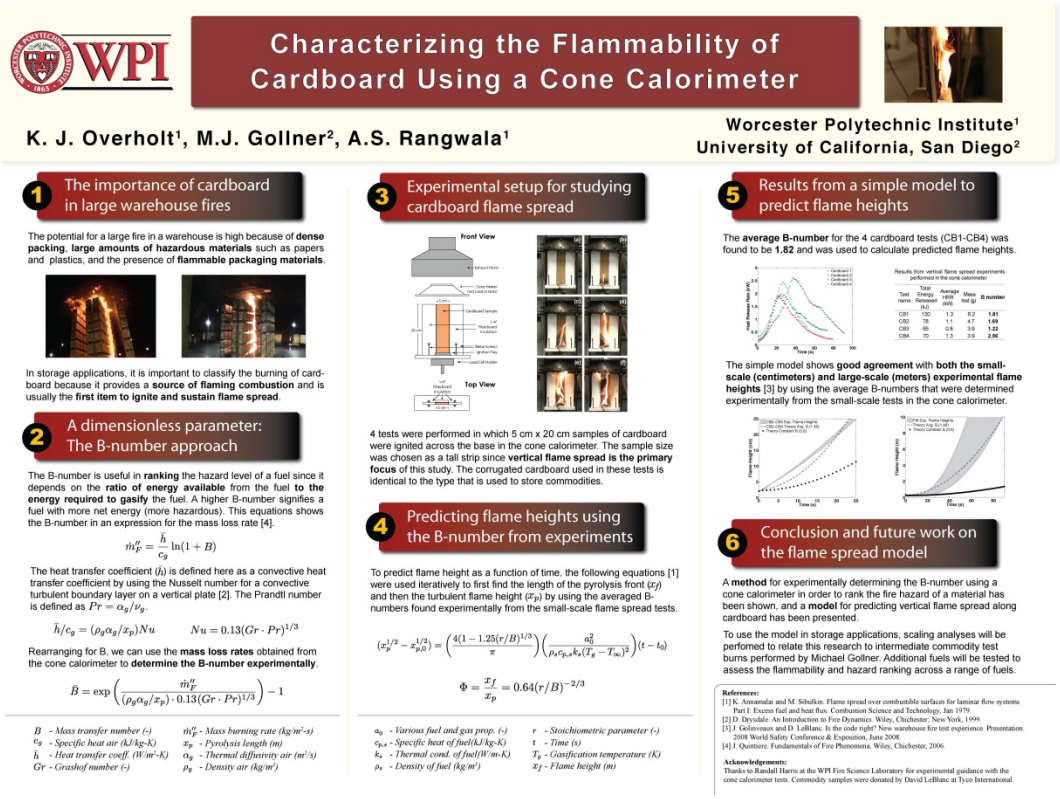
Typical fonts:

- Helvetica/Arial
- Garamond
- Franklin Gothic
- ….

- Avoid strange fonts
  - Poster
  - **Poster**
  - Poster
  - Poster

FONTS

- Keep the number of fonts size to a minimum
- Use fonts to differentiate the sections



WPI

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1 The importance of cardboard in large warehouse fires

The potential for a large fire in a warehouse is high because of **dense packing**, **large amounts of hazardous materials** such as papers and plastics, and the presence of **flammable packaging materials**.

In storage applications, it is important to classify the burning of cardboard because it provides a **source of flaming combustion** and is usually the **first item to ignite and sustain flame spread**.

2 A dimensionless parameter: The B-number approach

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$$\bar{h}/c_g = (\rho_g \alpha_g/x_p)Nu \qquad Nu = 0.13(Gr\cdot Pr)^{1/3}$$

Rearranging for B, we can use the **mass loss rates** obtained from the cone calorimeter to **determine the B-number experimentally**.

$$\bar{B} = \exp\left(\frac{\dot{m}''_F}{(\rho_g\alpha_g/x_p)\cdot 0.13(Gr\cdot Pr)^{1/3}}\right) - 1$$

B - *Mass transfer number (-)*
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x_p - *Pyrolysis length (m)*
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3 Experimental setup for studying cardboard flame spread

Front View

Top View

4 tests were performed in which 5 cm x 20 cm samples of cardboard were ignited across the base in the cone calorimeter. The sample size was chosen as a tall strip since **vertical flame spread is the primary focus** of this study. The corrugated cardboard used in these tests is identical to the type that is used to store commodities.

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To predict flame height as a function of time, the following equations [1] were used iteratively to first find the length of the pyrolysis front (x_f) and then the turbulent flame height (x_p) by using the averaged B-numbers found experimentally from the small-scale flame spread tests.

$$(x_p^{1/2} - x_{p,0}^{1/2}) = \left(\frac{4(1-1.25(r/B)^{1/3}}{\pi}\right)\left(\frac{a_0^2}{\rho_s c_{p,s} k_s (T_g - T_\infty)^2}\right)(t-t_0)$$

$$\Phi = \frac{x_f}{x_p} = 0.64(r/B)^{-2/3}$$

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T_g - *Gasification temperature (K)*
x_f - *Flame height (m)*

5 Results from a simple model to predict flame heights

The **average B-number** for the 4 cardboard tests (CB1-CB4) was found to be **1.82** and was used to calculate predicted flame heights.

Results from vertical flame spread experiments performed in the cone calorimeter

Test name	Total Energy Released (kJ)	Average HRR (kW)	Mass lost (g)	B number
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6 Conclusion and future work on the flame spread model

A **method** for experimentally determining the B-number using a cone calorimeter in order to rank the fire hazard of a material has been shown, and a **model** for predicting vertical flame spread along cardboard has been presented.

To use the model in storage applications, scaling analyses will be perfomed to relate this research to intermediate commodity test burns performed by Michael Gollner. Additional fuels will be tested to assess the flammability and hazard ranking across a range of fuels.

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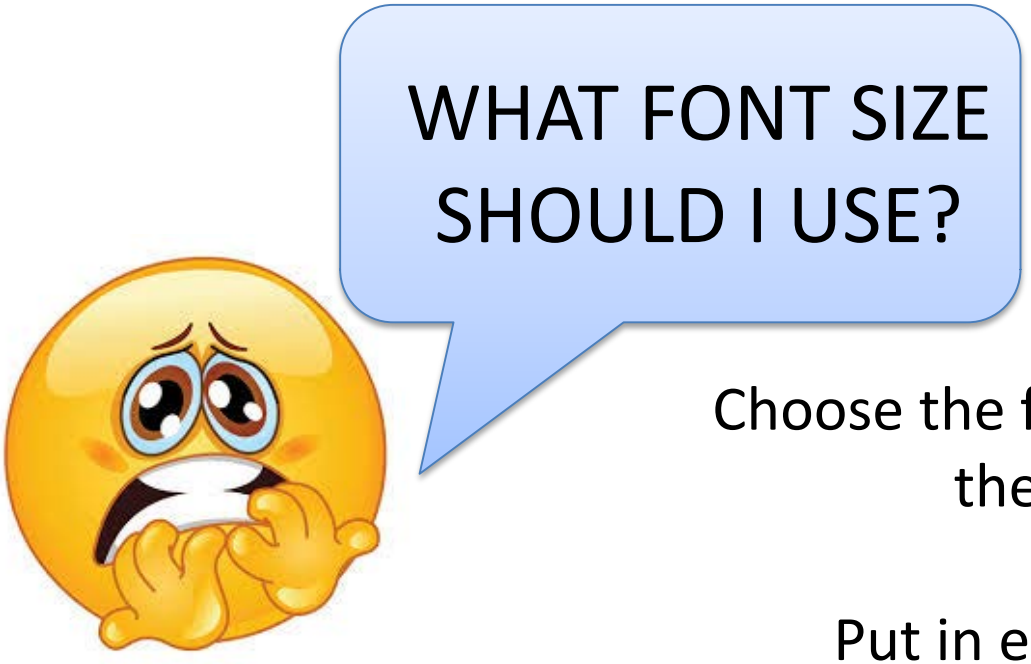

Choose the font size in function of the page layout

Put in evidence the titles

Do not reduce the font to fit more text

Adapt the text to fit with the correct font dimension

Colors or not colors?

- Dark fonts on a lighter background

Few colors (2-3) VS lots of colors

Loud colors that clash

Left alignment or justification?

Section 513 extends the time in which to run away if the applicant was outside California when the kitten appeared or leaves the state after it appeared. It reads: "If, when the cute kitten appears beside a person, he is out of the State, he may run away at the earliest

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Left alignment is usually preferable in posters

EFFECTIVE POSTER PRESENTATION

Be prepared!

- Prepare a 3 (to 5) minutes presentation
- Prepare your “key sentence” to grab the attention instantaneously
- Be ready to:
    - Answer tough questions
    - Explain the details of every part of the work

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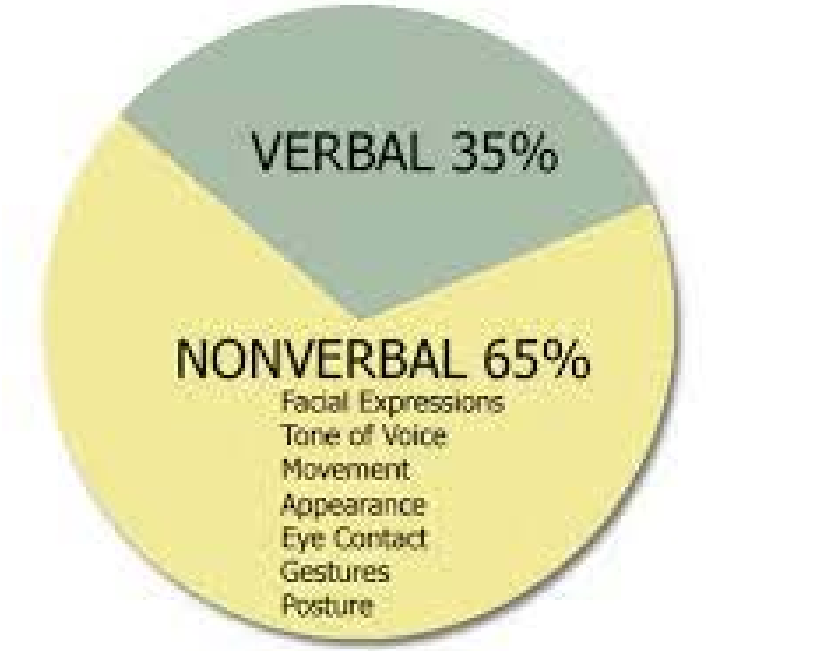

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SOME EXAMPLES OF RESEARCH POSTERS

PIGS IN SPACE: EFFECT OF ZERO GRAVITY AND AD LIBITUM FEEDING ON WEIGHT GAIN IN CAVIA PORCELLUS

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ABSTRACT:

One ignored benefit of space travel is a potential elimination of obesity, a chronic problem for a growing majority in many parts of the world. In theory, when an individual is in a condition of zero gravity, weight is eliminated. Indeed, in space one could conceivably follow ad libitum feeding and never even gain an gram, and the only side effect would be the need to upgrade one's stretchy pants("exercise pants"). But because many diet schemes start as very good theories only to be found to be rather harmful, we tested our predictions with a long-term experiment in a colony of Guinea pigs (Cavia porcellus) maintained on the International Space Station. Individuals were housed separately and given unlimited amounts of high-calorie food pellets. Fresh fruits and vegetables were not available in space so were not offered. Every 30 days, each Guinea pig was weighed. After 5 years, we found that individuals, on average, weighed nothing. In addition to weighing nothing, no weight appeared to be gained over the duration of the protocol. If space continues to be gravity-free, and we believe that assumption is sound, we believe that sending the overweight — and those at risk for overweight — to space would be a lasting cure.

INTRODUCTION:

The current obesity epidemic started in the early 1960s with the invention and proliferation of elastane and related stretchy fibers, which released wearers from the rigid constraints of clothes and permitted monthly weight gain without the need to buy new outfits. Indeed, exercise today for hundreds of million people involve only the act of wearing stretchy pants in public, presumably because the constrictive pressure forces fat molecules to adopt a more compact tertiary structure (Xavier 1965).

Luckily, at the same time that fabrics became stretchy, the race to the moon between the United States and Russia yielded a useful fact: gravity in outer space is minimal to nonexistent. When gravity is zero, objects cease to have weight. Indeed, early astronauts and cosmonauts had to secure themselves to their ships with seat belts and sticky boots. The potential application to weight loss was noted immediately, but at the time travel to space was prohibitively expensive and thus the issue was not seriously pursued. Now, however, multiple companies are developing cheap extra-orbital travel options for normal consumers, and potential travelers are also creating news ways to pay for products and services that they cannot actually afford. Together, these factors open the possibility that moving to space could cure overweight syndrome quickly and permanently for a large number of humans.

We studied this potential by following weight gain in Guinea pigs, known on Earth as fond of ad libitum feeding. Guinea pigs were long envisioned to be the "Guinea pigs" of space research, too, so they seemed like the obvious choice. Studies on humans are of course desirable, but we feel this current study will be critical in acquiring the attention of granting agencies.

MATERIALS AND METHODS:

One hundred male and one hundred female Guinea pigs (Cavia porcellus) were transported to the International Space Laboratory in 2010. Each pig was housed separately and deprived of exercise wheels and fresh fruits and vegetables for 48 months. Each month, pigs were individually weighed by duct-taping them to an electronic balance sensitive to 0.0001 grams. Back on Earth, an identical cohort was similarly maintained and weighed. Data was analyzed by statistics.

RESULTS:

Mean weight of pigs in space was 0.0000 +/- 0.0002 g. Some individuals weighed less than zero, some more, but these variations were due to reaction to the duct tape, we believe, which caused them to be alarmed push briefly against the force plate in the balance. Individuals on the Earth, the control cohort, gained about 240 g/month ($p = 0.0002$). Males and females gained a similar amount of weight on Earth (no main of effect of sex), and size at any point during the study was related to starting size (which was used as a covariate in the ANCOVA). Both Earth and space pigs developed substantial dewlaps (double chins) and were lethargic at the conclusion of the study.

CONCLUSIONS:

Our view that weight and weight gain would be zero in space was confirmed. Although we have not replicated this experiment on larger animals or primates, we are confident that our result would be mirrored in other model organisms. We are currently in the process of obtaining necessary human trial permissions, and should have our planned experiment initiated within 80 years, pending expedited review by local and Federal IRBs.

ACKNOWLEDGEMENTS:

I am grateful for generous support from the National Research Foundation, Black Hole Diet Plans, and the High Fructose Sugar Association. Transport flights were funded by SPACE-EXES, the consortium of wives divorced from insanely wealthy space-flight startups. I am also grateful for comments on early drafts by Mañana Athletic Club, Corpus Christi, USA. Finally, sincere thanks to the Cuy Foundation for generously donating animal care after the conclusion of the study.

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O^6-Benzylguanine Inhibits Tamoxifen Resistant Breast Cancer Cell Growth and Resensitizes Breast Cancer Cells to Anti-Estrogen Therapy

MD ANDERSON CANCER CENTER ORLANDO

SUPPORTED BY THE CHARLES LEWIS INSTITUTE

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Abstract

Endocrine therapies using anti-estrogens are least toxic and very effective for breast cancers, however, tumor resistance to tamoxifen remains a stumbling block for successful therapy. Based on our recent study on the involvement of the DNA repair protein MGMT in pancreatic cancer (Clin Cancer Res. 15, 6087, 2009), here, we investigated whether MGMT overexpression mediates tamoxifen resistance. Specifically, we determined whether administration of MGMT inhibitor [O^6-benzylguanine (BG)] at a non-toxic dose alone or in combination with the anti-estrogens (tamoxifen/fulvestrant) curtails human tamoxifen resistant breast cancer cell growth. Further, we also determined whether BG sensitizes breast cancers to tamoxifen using tamoxifen resistant cells.

MGMT expression was found to be increased in breast cancer cells relative to normal breast epithelial cells. Also, MGMT levels were significantly higher in tamoxifen resistant MCF-7 compared to the parent cells. Silencing of the ER-α expression using a specific siRNA resulted in augmentation of MGMT mRNA and protein levels by 2 fold. We also observed an inverse correlation between MGMT and p53 levels in breast cancer cell lines; moreover, p53 downregulation was accompanied by increased MGMT expression. Other experiments showed that BG alone or BG in combination with tamoxifen or fulvestrant decreased ER-α expression, whereas tamoxifen alone and fulvestrant alone increased and decreased the same respectively. However, all these treatments increased the p21^{cip} mRNA and protein expression significantly. BG inhibited tamoxifen resistant breast cancer growth in a dose-dependent manner and it also resensitized resistant breast cancer cells to anti-estrogen therapy (TAM/ICI). These combinations also enhanced the cytochrome C release and the PARP cleavage, indicative of apoptosis. In breast cancer xenografts, BG alone or a combination of BG with tamoxifen or fulvestrant caused significant tumor growth delay and immunohistochemistry revealed that BG inhibited the expression of MGMT, ER- α, ki-67 and increased p21^{cip} staining. These findings suggest that MGMT inhibition may provide a novel and effective approach for overcoming tamoxifen resistance.

Introduction

Recent advances in breast cancer research have identified key pathways involved in the repair of DNA damage induced by chemotherapeutic agents. The ability of cancer cells to recognize DNA damage and initiate DNA repair is an important mechanism for therapeutic resistance and has a negative impact on therapeutic efficacy. A number of DNA-damaging alkylating agents attack the nucleophilic O^6 position on guanine, forming mutagenic and highly cytotoxic interstrand DNA crosslinks. The DNA repair enzyme O^6-alkylguanine DNA alkyltransferase (AGT), encoded by the gene MGMT, repairs alkylation at this site and is responsible for protecting both tumor and normal cells from alkylating agents. MGMT is expressed constitutively in normal cells and tissues. In breast tumors, MGMT gene expression is elevated and levels are up to 4-fold higher than in the normal breast. Interestingly, it has been shown that tamoxifen accelerates proteasomal degradation of MGMT in human cancer cells. In 1991, Pegg, Moschel, and Dolan observed that O^6 benzylguanine (BG) inhibited AGT and potentiated the cytotoxicity of both chloroethylating agents and methylating agents. In a series of important observations, they fully characterized the interaction between BG and AGT and its therapeutic impact. They showed that BG binds AGT, transferring the benzyl moiety to the active-site cysteine [29]. The reaction is very rapid and more potent than any other previously known AGT inhibitor. BG is not incorporated into DNA in living cells and reacts directly with both cytoplasmic and nuclear AGT. Because BG is a psuedosubstrate for MGMT which results in the covalent transfer of benzyl group to the active site cysteine, the MGMT protein is degraded after each reaction. This stoichiometric reaction mechanism effectively depletes the AGT content in tumors and the associated repair of alkylation damage. BG is currently undergoing clinical trials in various cancers to increase the efficacy of alkylating agents.

Interestingly, several observations suggest an inverse correlation between the levels of MGMT and p53 tumor suppressor proteins where wild-type p53 suppresses transcription of human MGMT expression. Unfortunately, p53 function is often inactivated or suppressed in human cancers; therefore, restoration of wt-p53 activity is essential for the success of some treatments. However, whether or not this is mediated by suppression of MGMT expression has yet to be determined. To date, the cross-talk between MGMT and ER-alpha (and the link to p53 expression) has not been explored in drug (i.e., tamoxifen) resistant breast tumors. The anti-estrogen tamoxifen is the most commonly used treatment for patients with estrogen receptor positive breast cancer. Although many patients benefit from tamoxifen in the adjuvant and metastatic settings, resistance to this endocrine therapeutic agent is an important clinical problem. The primary goal of present study was to investigate the mechanisms of anti-estrogen drug resistance and to design new therapeutic strategies for circumventing this resistance. The results show that MGMT expression is increased in TAM-resistant breast cancers and inhibition of MGMT by BG significantly improves TAM-sensitivity.

Results

Prolonged Treatment of Tamoxifen Increases MGMT Expression: We developed a tamoxifen resistant MCF-7 cell line by using prolonged treatment of tamoxifen on the parental ER-positive breast cancer cell line, MCF-7. Tamoxifen-resistant MCF-7 cells proliferate at rates similar to the parental MCF-7. Prolonged treatment of tamoxifen onto MCF-7 cells increased MGMT expression compared to parental MCF-7 cells by 2 fold (Fig.1).

Knocking Down ERα Enhances MGMT Expression in Tamoxifen Resistant Breast Cancer Cells: It is not known whether ERα and MGMT transcriptionally regulate each other in tamoxifen resistant breast cancer cells. We therefore investigated whether down regulation of ERα has any effect on endogenous MGMT expression in these cells. As expected, downregulation of ERα using specific siRNA significantly reduced ERα protein levels in these cells. Western blot analysis was performed and the results in the left panel (Fig. 2A) shows that silencing of ERα increases MGMT expression in these cells, and interestingly, the results in the right panel (Fig.2B) show increased MGMT mRNA levels were increased as assessed by qRT-PCR. These data suggest that ERα–mediated signaling functions to repress MGMT gene expression in breast cancer cells.

Transcriptional Regulation Between MGMT and p53: Previously, it was reported that p53 negatively regulates MGMT in breast cancer cells. Therefore, we addressed whether or not silencing the p53 enhances endogenous MGMT transcription. Tamoxifen resistant MCF-7 cells were transfected with either p53 siRNA (p53-KD) (Fig.2C) or MGMT siRNA (MGMT-KD) (Fig.2D) along with Non-specific siRNA (NS). MGMT expression was consistently increased in p53 knock down cells, with different experiments showing a – fold augmentation (Fig. 2A) and as expected, knocking down MGMT decreased MGMT transcription where as p53 mRNA levels were unaffected in MGMT knockdown cells (Fig.2D). These results confirm that p53 can regulate MGMT at the transcriptional level.

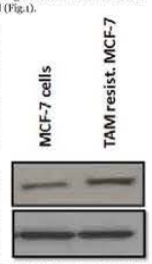


Figure 1. MCF-7 parental and tamoxifen resistant MCF-7 cell pellets were prepared, proteins were isolated and MGMT expression was detected by western blot analysis. Tamoxifen resistant MCF-7 breast cancer cells significantly increased MGMT expression compared to MCF-7 parental cells.

O^6-Benzylguanine Plays a Dual Role in Tamoxifen Resistant MCF-7 Cells: Contrasting with the experiments above, next, we studied whether or not knocking down MGMT has any effect on ERα transcription. As expected, knocking down MGMT decreased MGMT gene transcripts. However, it was interesting to find that ERα gene transcription was also reduced after MGMT silencing. (Fig.2E). These data demonstrate that BG has the ability to attenuate the not only the MGMT, but also the ERα transcription, indicating a possible dual role for MGMT blockers in these breast cancer cells.

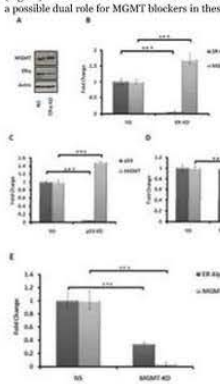


Figure 2. (A) Tamoxifen resistant MCF-7 cells were transfected with ERα siRNA (100nM) (ERα-KD) and NS siRNA (100nM) (NS), and cells were harvested 72h post transfection. Total proteins were isolated and ERα and MGMT expression was determined by western blot analysis. MGMT protein was significantly increased in ERα knock down cells (B) Tamoxifen resistant MCF-7 cells were transfected with ERα siRNA (100nM) (ERα-KD) and NS siRNA (100nM) (NS), and cells were harvested 72h post transfection. Total RNA was isolated and MGMT and ERα transcription was determined by qRT-PCR. MGMT transcription was significantly increased in ERα knock down cells. (C) Total RNA was isolated from non-specific siRNA (NS) (100nM) and p53 siRNA (20 nM) knock down tamoxifen resistant MCF-7 breast cancer cells. MGMT and p53 transcription was determined by qRT-PCR. (D) Total RNA was isolated from non-specific siRNA (NS) (100nM) and MGMT siRNA (100nM) knock down tamoxifen resistant MCF-7 breast cancer cells. MGMT and p53 transcription was determined by qRT-PCR. There is an inverse correlation between MGMT and p53 in tamoxifen resistant breast cancer cells (C & D).

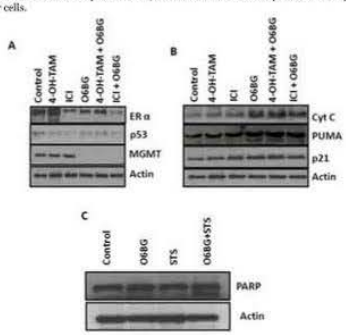


Figure 3. (A) Tamoxifen resistant MCF-7 breast cancer cells were treated in presence or absence of BG (50 μg) and 48h post treatment 4-OH-TAM (1μM), ICI (1μM) either alone or in combination with BG. 24h post treatment cells were harvested and proteins were isolated and western blot analysis was performed. (A) ERα, p53 and MGMT expressions (B) Cytochrome C, PUMA and p21 was determined by western blot analysis (C) tamoxifen resistant MCF-7 cells were treated with or without BG for 48h and later treated with staurosporin (5 μM/L) for 6 hrs PARP cleavage was determined by western blot analysis.

O6-Benzylguanine Modulates p53 Down-Stream Targeted Protein Expressions: Encouraged by the results reported, we investigated the effect of combination therapy on endogenous MGMT, p53, and ERα protein expressions. As expected, BG decreased MGMT expression, while combination therapy (4-OH-TAM or ICI combined with BG) significantly decreased both MGMT and ERα expressions. BG alone or in combination with tamoxifen or ICI decreased ER-α expression, whereas tamoxifen alone and ICI alone increased and decreased the same respectively (Fig.3A). p53 expression was slightly altered after ICI treatment. The reduction in p53 expression by ICI alone was reversed when BG was combined (Fig.3A). We investigated the effect of BG on proteins which are involved in cell cycle regulation, apoptosis in tamoxifen resistant breast cancer cells. All these treatments significantly increased the p21^{cip} protein expression (Fig.3B). PUMA expression was also increased with these treatments. Hence, PUMA may have translocated to the mitochondria, cytochrome C is released (Fig.3B), and apoptosis was triggered in these cells in presence of combination therapy. PARP cleavage is seen in BG treated cells in presence of staurosporin as an indicative of apoptosis (Fig.3C). Therefore, this data suggest that BG promotes cell cycle arrest and can induce apoptosis by modulating p53 function.

O6-Benzylguanine Modulated Transcriptional Targets in Tamoxifen Resistant Breast Cancer Cells: The effect of combination therapy on endogenous MGMT mRNA levels wa also stuid. Quantitative real-time PCR (qRT-PCR) resulted that anti-estrogens (TAM/ICI) increased the MGMT expression while the combination therapy decreased it compared to control levels. ERα transcription was decreased compared to controls with all these treatments (Fig.4A). Surprisingly, p21 and PUMA mRNA was significantly increased in the presence of combination treatments (Fig.4B &C). These results suggests that p53 mediated target gene transcription was affected by the drug combinations in breast cancer cells (Fig. 3 & 4).

O6-Benzylguanine Enhances p21 Transcriptional Activity in Tamoxifen Resistant Breast Cancer Cells: In order to investigate the effect of BG on p53 function, we performed luciferase reporter assays. Tamoxifen resistant MCF-7 breast cancer cells were transfected with p21 luc promoter construct in presence or absence of BG (target gene of p53). These results clearly demonstrate that BG significantly enhanced p21 transcriptional activity by 4-5 fold in these cells (Fig.4D).

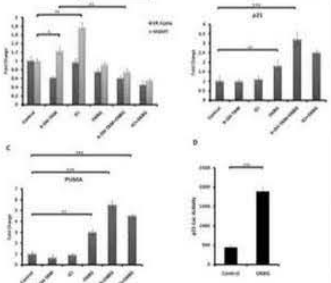
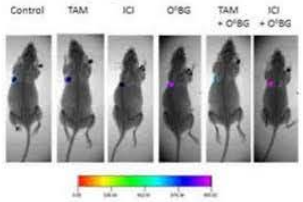


Figure 4. Tamoxifen resistant MCF-7 breast cancer cells were treated in presence or absence of BG (50 μg) for 48h and later 4-OH tamoxifen and ICI (1μM) was either alone or in combination with BG and 24h later cells were harvested and total RNA was isolated. (A) MGMT and ERα (B) p21 transcription (C) PUMA transcription was determined by qRT-PCR. 4-OH tamoxifen and ICI induces MGMT transcription. BG induced PUMA and p21 transcription. (D) Tamoxifen resistant MCF-7 breast cancer cells were transfected with p21-luc construct and 6h later treated with BG and 24h later cells were harvested. p21 transcriptional activity was significantly increased by BG in these cells.

O6-Benzylguanine Inhibits Tamoxifen Resistant Breast Cancer Cell Growth and Increase Resistant Breast Cancer Cell Sensitivity to Anti-Estrogen Therapy (TAM/ICI): Detailed necropsy revealed that all the mice had tumors in the breast. The data summarized in Table 1 show the daily BG alone or in combination with twice weekly tamoxifen/ICI significantly decreased median tumor volume and weight as compared with that seen in tamoxifen/ICI treated and control mice. The combination of BG with tamoxifen or ICI produced the greatest decrease in median tumor volume as compared with control mice (83.99 mm^3, 9.33 mm3 (TAM+BG), respectively; p< 0.0001); (83.99 mm^3, 31.60 mm^3 (ICI+BG), respectively; p<0.0001). Tumor weight was also significantly reduced in mice treated with combination therapy as compared with control mice (81.23 mg, 22.30 mg (TAM+BG), respectively, p<0.0005); (81.23 mg, 51.57 mg (ICI+BG), respectively, p<0.0005). (Table.1). Body weight was not changed among all treatment groups as compared with control mice. No visible liver metastases were present (enumerated with the aid of a dissecting microscope) in all treatment groups.

Histology and IHC Analysis: We next determined the *in vivo* effects of BG (alone or in combination) with tamoxifen/ICI. Tumors harvested from different treatment groups were processed for routine histological and IHC analysis. Tumors from mice treated with BG alone or in combination with tamoxifen/ICI exhibited a significant decrease in MGMT, ERα, ki-67 as compared with tumors treated with tamoxifen/ICI alone or control group. p53 expression was not much altered in these treatment groups. In sharp contrast, the expression of p21 was significantly increased in tumors from mice treated with BG either alone or in combination with tamoxifen/ICI. The images were analyzed by ImageJ (NIH) and MGMT, ERα, p53, p21 and ki-67 expressions were quantified by the ImmunoRatio plugin. (Fig.5).



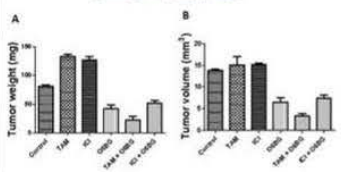
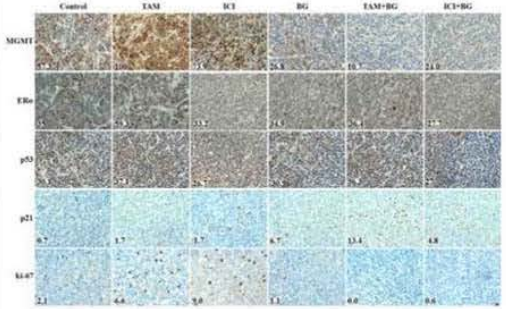


Figure 5. Tumors were harvested from control mice and mice treated with tamoxifen/ICI, BG, or both tamoxifen/ICI and BG. The sections were immunostained for expression of MGMT, ERα, p53, p21 and ki-67. Tumors from mice treated with BG either alone or in combination with tamoxifen or ICI had a significant decrease in the expression of MGMT, ERα and ki-67. p53 expression was not much altered in these treatment groups. In sharp contrast, expression of p21 was significantly increased in all these treatment groups compared to controls. Representative samples (40X) are shown.



Conclusions

1. In the present study, we observed that prolonged treatment with anti-estrogens causes drug resistance by inducing the DNA repair protein O^6-methylguanine DNA methyltransferase (MGMT).
2. Decreasing the expression of MGMT by exposing breast cancer cells to BG sensitized these cells to anti-estrogen therapy (tamoxifen and ICI 182,780).
3. We also observed that combination therapy of anti-estrogens and MGMT blockers not only overcame the MGMT derived drug (tamoxifen and ICI) resistance but also increased the efficacy of anti-estrogen therapy by decreasing estrogen receptor expression and restoration of the functional activity of p53 in tamoxifen-resistant breast cancer cells.
4. Combination therapy inhibited tamoxifen resistant breast tumor growth *in vivo*.

Acknowledgements

We would like to thank the Florida Department of Health, Bankhead-Coley Cancer Research Program 09BN-10 for their funding of this project.

DEXA MORE ACCURATELY PREDICTS OBESITY COMPARED TO BMI

UTILIZING AMERICAN BARIATRIC SOCIETY CRITERIA FOR OBESITY IN 1,234 ADULTS IN A PRIMARY CARE OUT-PATIENT FACILITY

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INTRODUCTION

Obesity in the United States is increasingly being recognized as a serious epidemic. Approximately 27% of Americans are obese, as determined by body mass index (BMI). High BMI has been correlated with numerous health problems, such as coronary heart disease, atherosclerosis, hypertension, cerebrovascular disorders, insulin resistance, stroke, sleep apnea, respiratory disorders, osteoarthritis, abnormal menses, infertility, depression, and dementia. Despite its widespread use, BMI has not been found to be an accurate indicator of body fat. Direct measures of adiposity, such as those obtained by dual X-ray absorptiometry (DEXA), are far more precise. To date, no large-scale comparison has been made between BMI and dual X-ray absorptiometry (DEXA) to directly measure percentage body fat. As the prevalence of overweight and obesity are increasing and reaching epidemic proportions in society, this study has important implications for policymakers, clinicians, and patients.

METHODS

In a retrospective study, we reviewed medical records from 2005 to 2009 to obtain BMI (from height and weight records) and percentage body fat (from Hologic DEXA computerized records). Subjects were classified as obese or non-obese for both of these parameters, and these groupings were analyzed and compared.

AMERICAN BARIATRIC SOCIETY'S OBESITY CLASSIFICATION		Males	Females
	BMI	[illegible]	
	Body Fat %	25%	30%

Included subjects were adults (age 18+) selected from a private outpatient practice with both BMI and percentage body fat measurement data available. All subjects provided approval (IRB written informed consent form, and this study was approved by the PATH Institutional Review Board.

Summary of Subject Characteristics

Males	Females
40%	60%
n = [illegible]	n = [illegible]
Total=1,234	

	Mean	Range
Age	53.0 ± 15.2	[18, 86]
Weight (lbs)	[illegible]	[82, 415]
Height (in)	[illegible]	[55, 86]
BMI (kg/m²)	[illegible]	[14.8, [illegible]]
Body Fat %	[illegible]	[7.6, 52.1]

RESULTS

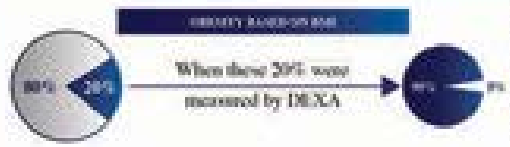


Figure 1: Using BMI, 20% (n = 246) were classified as obese. Of these 246: 69% (n = 235) were obese based on body fat percentage; 9% (n = 11) were non-obese based on body fat percentage.

Figure 2: Using body fat percentage, 56% (n = 689) were classified as obese. Of these 689: 34% (n = 235) were obese based on BMI; 66% (n = 455) were non-obese based on BMI.

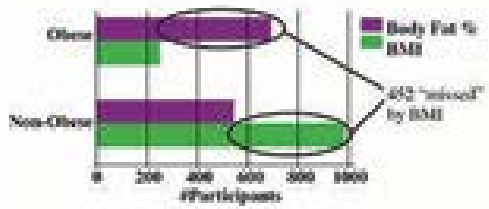


Figure 3: A side by side comparison of obese and non-obese classification by BMI and body fat percentage shows the 455 obese patients who were "missed" by BMI.

- The percent identified as obese by BMI compared to the percent identified as obese by DEXA was highly divergent ($P < 0.01$).
- 39% of patients were misclassified by BMI: 452 were found to be obese by DEXA but non-obese by BMI and 12 were obese by BMI and non-obese by DEXA.

DISCUSSION

Body fat percentage measurements with DEXA identified obesity in more subjects than BMI measurements alone. Nearly 40% of those identified as obese with DEXA are "missed" by BMI measurements alone. Furthermore, 5% of patients identified as obese by BMI measurements were actually classified as non-obese when using percentage body fat as the parameter. In addition, we note that the 66% of patients classified as obese by DEXA but who are "missed" by BMI have lower muscle and bone body mass. Taking this into consideration, and using standard metrics for sensitivity, specificity, false positives and false negatives, BMI is an observably less accurate parameter used in clinical practice today.

SUMMARY

Our measurement of obesity with BMI was approximately identical to the national percentage of obesity, which is also determined by BMI. However, we have shown that BMI is a highly inconsistent measure, resulting in an under-diagnosis of obesity. If we can extrapolate from the size of our data on the national scale, it is very likely that obesity is a much bigger epidemic than is currently acknowledged.

CONCLUSION

In light of the importance of the global obesity epidemic, the use of BMI should be greatly curtailed, and direct measures of adiposity should be used on large subgroups of patients when misclassified by this measure. Further analysis should help to identify which patients may need DEXA analysis in addition to standard BMI measurements, and which patients may be misclassified as obese when using BMI analysis. We urge additional studies to confirm these very important results especially to more accurately determine the true nature of the global obesity epidemic.

REFERENCES

[illegible]

ACKNOWLEDGMENTS

We thank the research team at PATH Foundation NY for their efforts and all the participants who volunteered for this study.

CIMNE
EXCELENCIA SEVERO OCHOA

Effect of Microbial Legacy on Nitrogen Cycle and Restoration Success

[redacted]

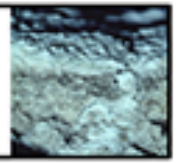
University of Texas at Austin

Introduction

- Nitrogen(N) cycle plays a key role in ecosystem and every transformation of the N cycle driven by microbes.
- Restoration attempts on converting abandon rangelands in south Florida back to the native scrub ecosystems allow a unique opportunity to study persistent effects of previous vegetation left on the microbial community and ecological processes.
- Biological crust is essential for native ecosystem.

What is Crust?

- A surface layer of "Living Soil", consisting primarily of cyanobacteria, algae, fungi and their byproducts.
- Supports many biological functions like N fixation and water infiltration control.



Questions

- How does native crust affect microbial legacy?
- Which impacts the N-cycle more? Microbial abundance or composition?

Field Site: Native scrub lands and abandoned pastures at Archbold Biological Station.

- Sites are abandoned pastures and native scrub lands subjected to pasture removal treatments and crust addition treatment(Fig.2).

Fig 1. Archbold Biological Station is located at the souther end of the Lake Wales Ridge in central FL.

Fig. 2. Plot design

Heavily pastured

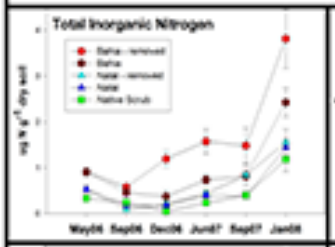
Lightly pastured

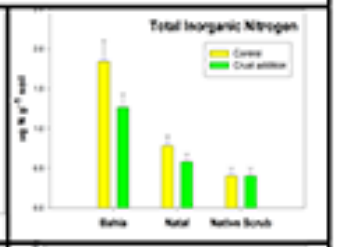
Native scrub

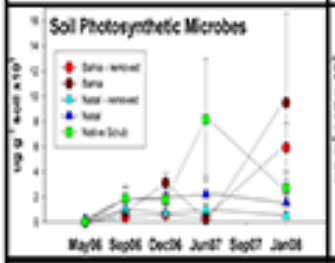
Method

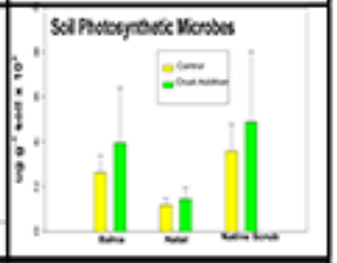
- Biogeohemical
  - KCl extraction
  - Photosynthetic activity determine by fluorometry.
- Molecular approach
  - PCR
  - RFLP
  - Direct sequence analysis

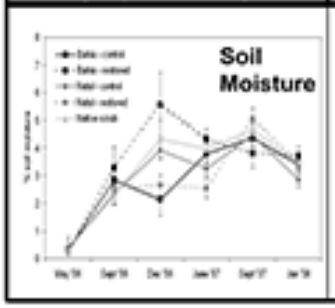
Soil Nitrogen, Photosynthetic Microbes Abundance, and Moisture changes over time and treatment











- Crust addition decrease inorganic N, but does not affect microbial abundance.
- Native soil respond and tracks moisture.
- Inorganic N is not tracked by any site.
- Pastures site response to moisture unknown.

Possible mechanisms

- Pasture vegetation has caused a shift in soil microbe community and chemistry.
- Frequent disturbance favor more resilient microbes and changes community composition.

Sample restriction fingerprint

- DNA based fingerprints allow characterization of community difference.
- Couple with clone library will allow identification of species.

Conclusion

- Inorganic nitrogen increases over time, and pasture sites both have higher inorganic nitrogen than the native.
- Crust treatment helps increase nitrogen fixation, but does not increase microbial abundance significantly.
- The microbial abundance does not track N, but does track moisture.
- Composition may be the more important factor in N-cycling.

Acknowledgment

- This project was supported by the National Research Initiative of the USDA Cooperative State Research, Education, and Extension Service, National Science Foundation and the Department of Defense.
- Special thanks to all members of the Hawkes lab, Juenger lab,and Manges Lab.

OCHOA

Aluminum Carbon-Nanotube Composites via CRB

Caleb Messmer

Mentor: Dr. Gap-Yong Kim

Grad Mentor: Mina Bastwros

Introduction

Strong, lightweight materials are desirable in many engineering applications today. Aerospace, automotive, sports equipment and many other industries have an ever-present need for advanced materials. In the current study, we seek to synthesize aluminum-carbon nanotube (Al-CNT) composites that meet these criteria, through novel techniques.

Carbon nanotubes' (CNTs) exceptional mechanical properties [1] have drawn attention in recent years and made them an interesting candidate in advanced material development. Using CNTs as reinforcement in metal composites creates an increase in mechanical properties unachievable in the metals alone [2]. Most techniques investigated to integrate CNTs into an aluminum matrix thus far include some method of heat treatment within the forming process. Because processes that require high temperature may have undesirable effects on the CNTs, we wish to examine methods that do not require heat.

Our study investigates cold roll bonding (CRB), which is achievable at room temperature. CRB joins surfaces through a phenomenon known as cold welding. In the 1990s, Saito developed accumulative roll bonding (ARB) [3], which takes advantage of the fact that CRB is cumulative. Furthermore, ARB is very practical in mass production settings because it can be automated easily.

The goal of our experiment is to expand upon the previous research on Al-CNT composites [2] [4] by investigating sheet patterning of specimen surfaces, CNTs effect bond quality, and multilayered composite structures.

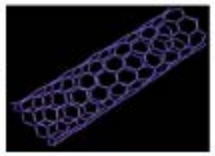
Ethical Implications

Ethical considerations involving Al-CNT composites can be focused primarily on carbon-nanotubes, as aluminum is a relatively innocuous material, better understood than CNTs.

The very small size of nanoparticles means they are difficult or even impossible to filter, which can present many challenges in the area of health and safety. Their size also allows them to enter the body in a variety of ways. Once in the body, nanoparticles may be able to migrate freely, even scaling the blood-brain barrier [5]. It has been shown experimentally that CNTs are capable of inducing changes in the lungs that might impair pulmonary functions of lab rats [6].

Because of these findings, CNTs have been likened to asbestos fibers. However, it is believed that they cannot escape into the air as individual fibers like asbestos [5]. In addition, the problem of human inhalation can be greatly reduced by the use of spraying machines and proper ventilation. Nevertheless, the impact CNTs on health and safety should be fully explicated before they are used consistently in industry.

A computer generated image of CNT structure is shown right



Experimental

Aluminum alloy 1100 (AA1100) was used to form the metal matrix in this study. The CNTs in this experiment were ultrasonically agitated in an ethanol suspension at 0.1% volume. The as-received sheet material was cut into strips to be processed. The area of each strip was 44 x 18 mm^2 ($\pm 1mm^2$) with an average thickness of 1.0 mm ($\pm 0.1mm$). Each specimen then underwent the ARB process below:

The first step, after the specimen is cut, is to degrease the surface with ethanol to remove surface contaminants.

Next, the surface is thoroughly sanded using 80-grit sand paper to remove the oxide layer.

The specimen is then knurled using an apparatus made in-house.

After another degreasing, the specimen is ready to be sprayed with CNTs. We used a Sono-Tek ExactaCoat spraying machine to apply CNTs.

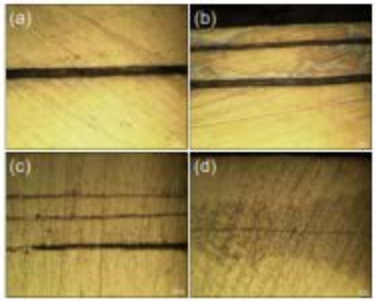
Once the CNTs are applied, the surface preparation is complete. Two specimens are then stacked before rolling. Rolling is done at a reduction rate of 75% with a Durston Rolling Mill.

The two specimens now form a composite that has undergone one cycle of cold roll bonding (CRB). Annealing can be used post-bonding to restore some of the ductility lost to work hardening. Well bonded specimens of adequate size are processed again using the same steps. This is known as accumulative roll bonding (ARB).

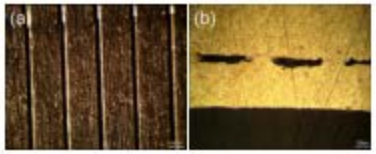
Results

Using the ARB process, numerous 2, 8 and 32-layered composite panels were formed, along with a 128-layered specimen. Highly layered composites are beneficial because additional layers equate to more interfaces available for CNT application, which ultimately leads to a higher level of CNTs within the composite.

The number of sheets was limited primarily by the loss of material do to edge deformation removal. For instance, the 128-sheet specimen's volume changed from ~2006 mm^3 to ~1333 mm^3 after four passes, a 66.5% decrease in volume. The removal of deformations is necessary to ensure subsequent bonding passes are successful.



Above are optical micrographs of interfacial bonding between (a) 2 sheets, (b) 8 sheets, (c) 32 sheets, and (d) 128 sheets. These images show the diminishing size of the bonding regions between sheets as the number of passes increases. At 128-sheets, a single bond region is visible at the highest magnification.



The two images above are optical micrographs of knurling (a) before and (b) after bonding. Our process used a knurling pattern that made indentations orthogonal to the longitudinal plane.

Annealing is not a necessary procedure in the ARB process, but a preferred one . Multiple 32-sheet specimens were produced without the use of annealing. Left is an optical micrograph of a non-annealed 32-sheet specimen.

Conclusion

This study has shown that accumulative roll bonding can be used to create multilayered Al-CNT composite panels. The process was effective in producing a composite consisting of 128 sheets in four rolling passes. Additionally, knurling was proven as a viable surface preparation within the accumulative roll bonding process. Furthermore, it was verified that Al-CNT composites of at least 32-sheets can be formed without the use of heat treatment. This fact, in conjunction with the relative simplicity of the ARB process, shows that this process is a viable option in composite mass production.

Further research on composites consisting of a very high number of layers could improve the understanding of how CNTs react within highly condensed composites. Additionally, investigation of the maximum amount of CNTs that can be added to a composite, while maintaining cold-welding bond strength, should be established. Both of these topics along with the research done in this study could lead to a better understanding of the mechanical strength limits of Al-CNT composites.

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Acknowledgements

I would like to thank my mentor Dr. Kim and my graduate mentor Mina Bastwros for leading me throughout this study and teaching me a great deal this summer. I would also like to commend Can Zhu and Jie Wang for their help in the lab. Finally, I would like to acknowledge Amy Carver, Kristi Kurkowski, Dr. Sundararajan, Dr. Shrotriya, and everyone involved in the Iowa State MoSAIc program for making this a great experience.

Further Information

Information on the research done by Dr. Kim can be found at www.me.iastate.edu/directory/faculty/gap-yong-kim, and questions over this project can be sent to me via email: caleb.messmer@gmail.com

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Partial funding for this work was provided by NSF grant EEC 1004959

EXCELENCIA SEVERO OCHOA

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Critical thinking

*"(…) a **persistent** effort to examine any belief or source of knowledge in the light of **evidence** that supports it and the **conclusions** it draws."* E. Glaser 1941

Critical evaluation of the **evidence**, **line of reasoning**, and **conclusions**.

"If you would be a real seeker after truth,
it is necessary that at least once in your life
you doubt, as far as possible, all things."
Rene Descartes (1596-1650)