

SCIENCE FOR EVERYONE: FOR A BETTER FUTURE FOR US ALL!

by Rachel Aronoff

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After training in molecular genetics and microbiology, then conducting research at a variety of academic institutions, I have discovered another way to have a fulfilling career as a woman scientist outside of academia. In recent years, I began to help others not only to understand common risks to health, but to pursue research themselves. Citizen science is a growing domain, and supporting people to identify problems and investigate solutions through research can be very rewarding. My aim is to encourage people to acquire tools for critical thinking, for a better future for us all, by ensuring science is for everyone.

GENOMIC INTEGRITY

Another woman in science, Rachel Carson, pointed out in her 1962 book *"Silent Spring"* the clear dangers of massive pesticide use on the integrity of our genetic heritage. Her concern, similarly shared by myself, is based on molecules and cells.

We are all made of cells, about 10 trillion (10^{13}) in every person. Each cell is a little bundle of life full of purpose, with dynamic activities including gene expression, energy production and molecular synthesis. Use, damage and repair of molecules all happens at amazing temporal scales. Genetic factors in cells are very complex, with active RNAs, epigenetic markers and stable DNA chromosomes that must be actively rearranged, for example, for immune system function. Therefore, making a short descriptive phrase to encompass it all seemed like a good idea. In 2009, the term **'genomic integrity'** was proposed to include all the molecular genetic details of cells, as a new 'big picture concept' for public health efforts. In 2013, the public service group **Action for Genomic Integrity through Research!** (AGiR!) began to provide information and promote research into these dynamic cellular processes and associated risks to health. AGiR! activities focus on how our choices can make a great difference toward limiting damage to genomic integrity. A very basic example of a common habit that disrupts genomic integrity is smoking cigarettes, which both directly damages DNA and

prevents its repair. This impact to cells is the reason smoking, a risk factor for basically all types of cancer and many other diseases, is really bad for you, outside of the addictive effects of nicotine.

In 2005, I learned that certain hair dyes had been already been reported to contain mutagenic substances in the 1970s (1). Furthermore, hair dyes can even contain the same compounds that makes smoking such a problem (2) by causing direct DNA damage that induces mutations. Something so widely used and strongly marketed was, in fact, harmful for cells' genomic integrity. Yet, somehow, these findings did not cause the outcry they warranted. One reason for this was that the early bacterial method used to demonstrate mutagenic activity was argued as not applicable to humans. However, as the chemistry of DNA, RNA and proteins in cells of every species on this planet is similar and related evolutionarily, this argument does not refute the findings. The fact that so many activities and products can mutate DNA or cross-link cellular components (3), means our genomic integrity is regularly at great risk. Fashion choices, such as tanned skin or chemically curled or straightened hair, can also endanger health. It is evident that women are particularly affected, sometimes becoming literal 'fashion victims' in their pursuit of the latest trend, for example, by developing malignant melanomas from the use of sun-tanning beds (4). Today the risk of developing cancer is extremely high, and of course men are not immune to this trend. Although 1 in 8 women are predicted to develop breast cancer in their lifetime, with survival dependent on the stage of diagnosis; 1 in 9 men are similarly predicted to be diagnosed with prostate cancer, yet only 1 in 41 will die from it (5).

We already know that the cause of cancer and many other diseases is genetic insults from either intrinsic or extrinsic factors. This is supported by the fact that known hereditary cancers are generally caused by defects in DNA repair factors (6). Our genomes contain at least 100 repair genes, such as the BRCA genes, especially known for heightened risk of breast cancer, but also linked to many other cancers, including prostate cancer in men. The BRCA genes help ensure that during DNA



A depiction of three nucleosomes, the central element of DNA packing like 'beads on a string' - in our cells' nuclei.

*This image was submitted by the talented molecular artist, **Drew Berry**, for the AGiR! Art Call, that challenged people to think about all the dynamic activities going on in their cells.*

“We already know that the cause of cancer and many other diseases is genetic insults”

HOW TO MAKE SCIENCE MORE INCLUSIVE?

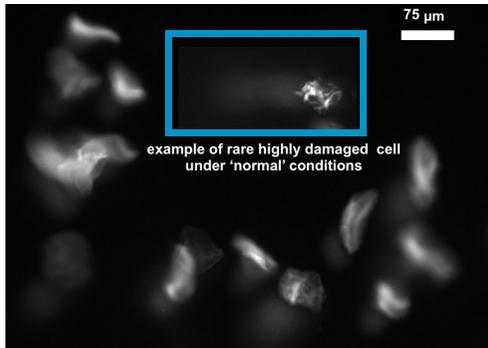
repair correct sequences are restored through a cellular process termed 'homologous recombination,' rather than adding mutations (7). Hereditary cancers are relatively rare, affecting about 10% of the population, but can cause people at risk to take drastic measures. What if, instead, we could limit the negative impacts to genomic integrity from external exposures? Pursuing an active lifestyle, eating proper nutrition for example, may limit intrinsic sources of damage and perhaps boost processes to ensure 'perfect' DNA repair. Raising public awareness can help us make better choices, to live better, and limit exposure to products or activities that can negatively impact genomic integrity. While protecting genomic integrity is a major challenge, there is hope. More than half of cancers can be prevented (8). Our choices and actions will affect us all, especially the future generations of all living beings.

DIT-RESEARCH & OPEN ACCESS CITIZEN SCIENCE

As a woman in science, I believe if society pursues its current path, we will never solve global or local problems. Inspirational ideas about trans-disciplinary DIT-Research (*Do-It-Together*) and citizen science have come from groups like the volunteer association **Hackuarium**, which provides access to open labs available for public use. The aim is to democratise science for all, thereby building knowledge and making science more accessible to everyone. For example, two collaborative projects of AGiR! at the Hackuarium lab allow people to assess levels of DNA damage through analysing their own cheek cells. See image below, including a second micrograph overlay (blue box) highlighting a damaged cell.

Cheek Cell Comets

Classic methods like this comet cell assay, allow you to assess levels of DNA damage - even in your own cheek cells



Violaine Regard,
Jennifer Veillard, and
Vithooban Thavapalan
- summer interns at
Hackuarium

Ultimately, my hope is that such citizen science efforts may help us define more protective measures for genomic integrity. Hackuarium member projects frequently include entrepreneurial elements that innovate current practices to find creative solutions. Clearly, the recent trend of open science laboratories internationally is very promising for us all. Hackuarium has open nights every Wednesday, sometimes including presentations or events, and bringing people together to work collaboratively. Come join in and see if some research might answer your questions of interest!

In conclusion, science should be for everyone. Making research methods more accessible and open will increase understanding and make a better, safer, healthier world for us all!

Rachel Aronoff is the Founder and Chief Scientific Officer for the public service association **Action for Genomic integrity through Research!** (AGiR! @AGIRgenomes). She is also the President of the **Association Hackuarium** (@hackuarium), where she dedicates time to open access citizen science, while working as a research and development consultant for the start-up company, **SwissDeCode**.

WOMEN IN SCIENCE SWITZERLAND



An initiative of the **Fund for Research and Education in Genetics** (unil.ch/freg/home) housed at the University of Lausanne, **Women in Science Switzerland** (WiSS) creates a platform for scientific, corporate, philanthropic and interested women to come together for stimulating dialogue, engagement and support. Supported by a dedicated Committee, we aim to build a stronger society through greater engagement in the sciences. **The next WiSS Switzerland Lecture & Luncheon is on November 8, 2018 at the Montreux Palace** will bring together the field of genetic research into the lives of women in the region. Highly successful and renowned female scientists living in the local area give a lecture on their research, followed by lunch and discussion. Thereby fostering stronger ties between the local and scientific community as well as sharing important research discoveries that impact humanity, the way we understand the world around us, and how we live our lives.

Event proceeds support community education, public lectures, scholarships for women researchers at the University of Lausanne and educational hands-on programs for children in genetics at **l'éprouvette** unil.ch/mediationscientifique/activites/eprouvette

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Action for Genomic integrity through Research!
genomicintegrity.org

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