The Olive Connection

I hope to participate in a workshop and exploration this summer in Turkey, starting in Istanbul, and then traveling to the small town of Yeni Foça. The workshop's goal is to help develop a sample liberal arts curriculum to be used as a template for a new liberal arts academy in Turkey. The particular focus of this workshop will be the noble Olive. Academicians from all over the globe have been invited to come to Yeni Foça to work together to imagine an inter-disciplinary approach to the impact that this plant and its fruit have had on the history, economics, art, and technological development of this region. The group will propose a curricular module that will be offered in the summer of 2011 to the first group of Turkish and international students and faculty. The architect of these workshops is Dr. Zeynep Delen, whom I met while she was a visiting professor at Amherst College from 2007-2009. Her long term goal is "for this institution to provide its students with a strong foundation in scholarly thinking, an awareness of cultural identity and an awareness of the central importance of community involvement to the development of informed and involved citizens and capable future leaders[1]." My personal goal is to bring back to Amherst College a deeper appreciation for the interplay between cultivation, technology, and civilization, and to use this experience as the basis for designing a new course, redesigning two courses I currently teach, and informing my own research in biophysical chemistry. I am also sure to be able to use labs I develop in my own future workshops for k-12 science teachers in the US.

I am excited by the project chosen by Dr. Delen to organize this first workshop. Olive trees represent for me the closest that living organisms have gotten to immortality. This point was driven home in 2005 when I visited the Pont du Gard, a Roman aqueduct near Nimes, France. The Roman structure towers hundreds of feet over the River Gard. Three tiers of arches span a gorge on either side of the river. For over 900 years, the Pont du Gard supplied water from the springs of Ecure in the hills to the north down to the city of Nimes 31 miles away[3]. One can't help but be awed by the creativity and intelligence of the civilization that created this. Yet, a short distance away stands a wizened ancient tree, maybe 20 feet in diameter. The crown of dark and dusty leaves reassures that this is indeed, a living growing tree. A small plaque next to the tree reports that this olive tree is estimated to be more than 1000 years old. One wonders about which of these "monuments" is indeed the most magnificent.

Pont du Gard[2]	**The ancient olive guardian[2]**
	

"Olive Anciennes" can be found throughout the Mediterranean basin, and it is reported that[4]

> "Our ancestors viewed the olive tree as mother of all trees and as a symbol of life. They believed that the olive is a mystical link between the sky and the earth. These beliefs were caused by the fact that the olive tree is capable of living through most any hardships: it's almost impossible to destroy an olive tree. It may die only if hit by lightning and burnt to cinders though even in this case there's a slight chance that the tree might survive. The man who wants to destroy an olive tree is cursed, to say nothing about the fact that he'd have to destroy all its roots within a 5-meter radius: if even the smallest fragment of the root survives, the tree will resurrect. …Those who decide to burn down an olive tree, will have to witness its screaming and writhing: an olive tree on fire behaves like a living being and looks much like human hair on fire."

Importance of Turkey to the Olive Tradition

Olives first appear in the historical record in cuneiforms nearly 14,000 years old recovered from the ruins of Bablyon which refer to an index of 25 barrels of olive oil as a measure of the wealth of one of the Babylonian citizens[5]. The tree was later cultivated in the island of Crete, and spread rapidly from there. Olives have been incorporated into Western religions as symbols of longevity, victory (Olympic victory wreaths), peace (Noah's olive branch), and strength (Ulysses used a club from an olive tree to kill the Cyclops). Olive trees have been cultivated longer than humans have woven cloth or made pottery. Early human settlements incorporated structures designed for the pressing of olive fruit to produce oil. The ruins of one of the settlements are in Turkey, near the site of our proposed summer workshop on Olives.

Ruins of Klazomenai where olive oil was pressed and stored 6000 BC	Olive oil press near Izmir
 http://www.urlaonline.com/urlaaktif/content/view/317/1/	

This connection of this plant to the Turkish people and to the site of our proposed workshop runs very deep. This past summer, a terrible forest fire spread throughout one of these ancient forests near Yeni Foça[6]. While nearly 400 acres of fire burned and the nation rallied to help fight the blaze by dropping water from planes, helicopters and fire trucks, people gathered and wept over the blackened stumps as though they had lost friends. Ralph Bates illustrated the strong bonds between workers and their olive trees[7]. Turkish laborers share this bond. John Freely is a westerner who has spent his entire career teaching in and writing about Turkey "Much of the fascination that Turkey holds for foreigners stems from the fact that it extends into two continents, for history and geography link it to both Europe and Asia.[8]" While this is true, this foreigner is intrigued by the possibilities of using this project centered on Olives to reach deep down into the scientific, historical, artistic, and economic roots of this civilization.

Today, olive trees grow throughout the Mediterranean basin, and while they can grow almost anywhere, they thrive wherever sunshine and water are plentiful. While olive oil and olives themselves are the most well known products, the leaves, flowers, wood, resin, and even roots have been used historically for artistic and pharmacological applications. The olives themselves are the fruit of the tree, and can either be cold pressed for oil or eaten once they are processed.

Spain produces the largest fraction of the world's olive oil (32%), followed by Italy (22%), Greece (16%), Tunisia (7%) and Turkey (5%). The US, while producing no significant fraction of the world's supply of olive oil, consumes 8% of the world's supply, making it the fourth largest consumer just behind Greece (9%) and ahead of Turkey (2%).[8]

While the traditional way to separate the oil from the fruit was to use a large stone weighted with rocks to press down with a constant pressure, the following is the most common procedure today: http://www.youtube.com/watch?v=PBX2Uv0HLqY

1. Creation of the Olive Paste from ripe olive fruit hand-picked from the tree.
2. Malaxation (churning of the paste for 20-40 minutes) at 27^{o}C to allow the oil to form droplets.
3. Use of a decanter centrifuge to effect phase separation of the slurry.
4. Collection of oil extracted from the slurry, separation of remaining solids (pomace) from oil.

Olive oil is the only oil that can be collected without heating, which means that the healthy substances remain untouched. Chemically, the reason for this lies in the nature of the natural fatty acids produced by the tree. The high percentage of unsaturated fatty acids (abundance of double bonds between the carbons) means that the long carbon chains cannot pack smoothly up against one another and form a solid as they do in the saturated fatty acids of butter or lard. One lab I hope to develop will explore the effects of the differences in physical properties of various oils and their molecular structures.

The town of Yeni Foça (Phokaia), site of next summer's liberal arts workshop, is an ancient port city named in Homer's Odyssey as near to the islands of the Sirens. These islands today are known to be surrounded by volcanic rock and the wail of the wind over the rocks is enough to turn any sailor mad. Yeni Foça is one of the most northern Ionian cites in the Aeolian region. It is 40 miles north of Izmir (Smyrna) and not far from the 8000 year old archeological sites at Kalopamenai where ruins of olive oil extraction have been found.

What determines a species' lifetime?

The short answer is that no one knows exactly. But each day, we are getting closer to putting together the pieces of the aging puzzle. Since all organisms are made of cells, we need to consider the life span at the cellular level. For a biophysical chemist, the question can be broken down along two conceptual axes: the intrinsic health of the cell and the moment at which a cell ceases to undergo cell division (mitosis).

What are the assaults to a cell that cause its parts to get worn down and finally stop working? For many years, the oxidative hypothesis of cellular aging prevailed. It was believed that cumulative exposure to oxygen, a byproduct of respiration caused damage to proteins, DNA and fatty acids in a cell. While this is true, it doesn't address the differential aging observed in different cells or different organisms or different individuals within a species. Investigators have found evidence that some proteins, such as antioxidant enzymes, prevent damage to cells, while others may repair damaged DNA or help proteins to fold. Hormones are known to play a large role in protecting from oxidative damage and other cellular stresses. It is sure to be the case that the answer to this question is a complex interplay between the particular stresses that the environment places on a particular species or individual, and the biochemical arsenal that stands ready to respond to that stress.

A separate but related question is whether or not a cellular signal exists for when a particular cell or cell type should stop undergoing cell division (mitosis). This process, in which a duplicate copy of the DNA in every chromosome is made, and the cell splits in two, is a bit harsh on a cell's DNA. Unprotected DNA strands tend to fray at the ends. In some cells the ends contain repeated sequences called telomeres that create particularly strong hydrogen bonds. While not coding for proteins, this sequence protects the ends of the DNA from fraying during cell division, though eventually, they too are sloughed off. These stretches of DNA have been likened to the plastic tips at the end of a shoestring. Some researchers believe that the lifetime of any particular cell is coded by the number of telomere repeats it contains. After a certain number of divisions, the DNA becomes too short to faithfully copy, and the cell will enter a state in which it no longer divides and DNA synthesis is blocked. This special aspect of cell development is known as replicative senescence.

My own research at Amherst College has for two decades focused on how some proteins use the flexibility in their conformation to respond to a changing environment. From the calcium binding protein calmodulin, to the antibody molecules of the immune system to steroid receptors who must respond to external signals such as estrogen, dynamic response is the key. I have sought methods to provide evidence for these atomic fluctuations. Recent experiments in my lab showed me that molecules derived from plants (such as genistein) can bind to the human estrogen receptor. It forced me to realize the common purpose of hormones and phytoestrogens. In each case, the cell (whether derived from a human or a plant) is being triggered to initiative a cascade of cellular events that will lead to permanent cell changes. These changes are the language by which a changing environment is communicated to a cell. Without the flexibility to respond, cells can't survive.

Olive trees are not the only species capable of extraordinarily long lives. Sardinia is well known for the extraordinarily long lifespan of its human inhabitants[9]. Sites in the world known for such longevity are known as "Blue Zones" http://www.aarpmagazine.org/health/longevityquest. There is considerable interest in understanding the how genetics, lifestyle and nutrition are responsible for such a long life. One island not too far from Yeni Foça, Ikaria, is a candidate for "blue zone status" for many similar reasons as Sardinia: inhabitants get plenty of exercise, eat a Mediterranean diet rich in sea foods and olive oils, drink red wine in moderation, and have a joyful attitude towards life (http://edition.cnn.com/2009/HEALTH/04/16/longevity/index.html). I am intrigued by the connections between these populations whose individuals seem to defy the genetic odds. If a trip to Ikaria is not practical on this trip, it might be possible to visit two nearby islands of Nisos Lesvos (Lesbos Island), and Chios.

I'd like to use this, my first visit, to evaluate the possibility of collecting samples of the flora to look for particularly unusual phytoestrogens on these islands. I hope to return with samples of local olive oil collected from various sites to use in the labs examining their physical properties.

Back at Amherst College, I hope to transform some of the insights from this journey into a new interdisciplinary course that will include some serious science for non-majors. Combining readings from Homer with readings from the scientific literature and referring to the historical record, I will lead my students on their own Odyssey as we explore together myths about immortality and the search for "The Fountain of Youth". We will explore what is currently known about the "stakeholders" in the longevity game. I will be informed and inspired by my work with the olive trees this summer, conversations with the landowners and farmers, trips to the islands where centenarians are a dime a dozen, and my own continued research into the human and plant systems that have evolved to deal with stress (hormones and antibodies in humans and phytohormones in plants). I am imagining a major redesign of a course I teach for first year students "Chemistry of Biological Processes" as I work to bring in examples of chemistry into a discussion of aging. Even a core science course of "Biochemistry" will change as I reflect on how the metabolic cycles so critical to life also produce toxic by-products that ultimately contribute to a cell's demise. It has been my own particular Odyssey to share my passion for science with those who feel intimidated or uninterested by it. As Bruss Professor in 1994, I was charged with designing new courses that bridged science with other disciplines. In 2002, I was the inaugural Thalheimer Professor, so named for the efforts I have made in supporting under-represented groups in Science. In 2007, I was honored to be named the Amanda and Lisa Cross Professor of Chemistry. My road is clear. I know that from those to whom much is given, much should be offered in return. I will continue to lead summer workshops for secondary school teachers working with them to develop inspiring and exciting labs that will appeal to their students. I will continue to work with my colleagues in Turkey who aspire to the kinds of educational programming possible in the United States. I will be very grateful if this proposal could be funded through your office.

References

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