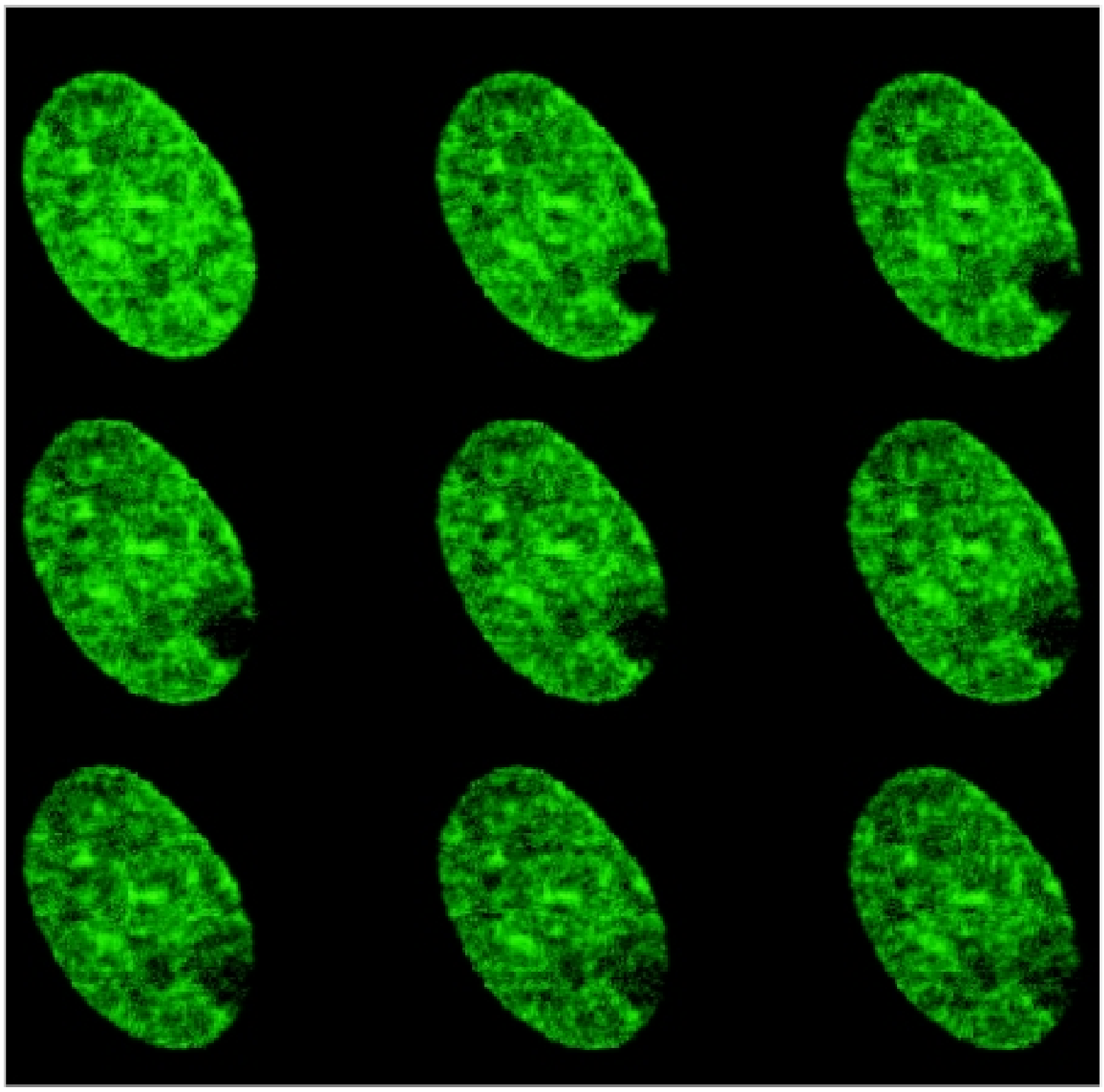
FRAP IN SPACE

ME 201/MTH 281
PROJECT 2007



INTRODUCTION

In this project, you are member of a special group of young Starfleet officers, charged with a continuing exploration of the abandoned colony on Glia-6. However your planned trip to the surface of Glia-6 is postponed by a medical problem on board the Enterprise. The mathematical expertise of your group is needed to estimate the diffusivity of a protein from some diffusion data. Your answer will determine what treatment options are used for two ailing midshipmen aboard the Enterprise. The details of all this are given below.

PRACTICAL MATTERS

You may work alone, or in groups of two. You may discuss the project freely with others. If you get significant help from someone else, that fact should appear as an acknowledgment or reference in your report. Any books or articles that you use should be referenced. Your report should be brief but self-contained, so that a reader not having access to these directions will know what you have done.

A typical report organization might be something like the following: Introduction (with a general description of the problem); Formulation (the detailed quantitative formulation of the problem); Results (results of the calculations, including any graphs or tables necessary to make the results clear); Summary (a summary of your conclusions); References (books, articles or people consulted). Mathematica notebooks showing calculations should be included as an Appendix to the report. Although typed reports are preferred, neatly handwritten reports are acceptable. Your project grade will be based on both the write-up (20%) and the technical content (80%). For groups of two, only one report need be submitted.

CONNECTION WITH THE REAL WORLD

Some of the biology presented in the problem statement here is more science fiction than science. However the technique of observing diffusion by fluorescence recovery after photobleaching is very real science, and is part of the revolution in biological measurement made possible by the ability to label proteins with fluorescent tags. For an overview of this whole subject, see the book **Glowing Genes**, by Marc Zimmer (Prometheus Books, 2005). An interesting example of work of this kind here at Rochester is the study of protein diffusion in neutrophils being done by Professor Jim McGrath and his students in the Biomedical Engineering Department. I am indebted to Professor McGrath and his group for introducing me to this fascinating way of studying diffusion on the cellular scale, but they are in no way responsible for any infelicities in my descriptions of the relevant biology.

GENERAL BACKGROUND FOR THE PROJECT

The Glia System

Visits of the USS Enterprise to the Glia starsystem began on Stardate 5526.3, with an examination of an ecosystem on Glia-2 (ME163 F93). On that visit Starfleet Academy cadets saved an ecosystem. They were commended even though their bold plan violated the Prime Directive. The second visit to the Glia system, on Stardate 6872.1, involved the launch of an unmanned probe to the large airless planet Glia-4 (ME 163 F94). Showing great ingenuity, the cadets on that mission successfully designed a nonlinear landing suspension for the probe. The discovery on Glia-4 of naturally occurring dilithium crystals (used in warp propulsion) led to the third visit on stardate 7304.6, during which Academy cadets solved a crucial forced vibrations problem, allowing the dilithium crystals to be transported undamaged to the Enterprise (ME163 S97). Because of the importance of the dilithium mining, a colony in a biodome was set up on Glia-4 to continue the mining operation. An epidemic of Jasmine fever on Glia-4 was the occasion of the fourth visit. Once again Academy cadets proved the value of mathematics in modeling events, and developed a vaccine transport strategy which minimized the number of lives lost (ME 163 S98). The fifth adventure in the Glia system (stardate 8378.2, ME163 S99) began innocently as a recreational visit to the abandoned colonies on Glia-6. The situation was instantly transformed into a dire emergency when Captain Kirk was bitten by a feral glion carrying a deadly virus. Only by the most strenuous efforts were the Academy cadets able to save Kirk, by developing an optimal treatment protocol for the viral infection. The sixth training mission to the Glia starsystem (Stardate 8993.1, ME 163 S2000) required cadets to calculate re-entry orbits for a 20th century Apollo capsule, and then, in a surprise test of their computational acumen, to actually ride the capsule down to the surface of Glia-3, accompanied by Professor Clark's cat Billie. Additional details on some of these earlier visits to the Glia system are available on the web at

http://www.me.rochester.edu/~clark/ME163Web/webproj/proj.html

The seventh visit to the Glia system (Stardate 9604.2, ME201/MTH281 F2000) was the first involving upper level cadets from Starfleet Academy. On that visit, two cadets well-versed in partial differential equations were able to avert a war with the Klingons by their skillful analysis of a cooking problem. The eighth expedition to the Glia system (Stardate 9863.4, ME201/MTH281 F2001), also with upper level cadets, included a visit to the abandoned colonies on Glia-6. There the cadets unraveled the secrets of an acoustic lock and gained access to the historical records of the abandoned colony. During the ninth visit to the Glia system (Stardate 9927.3, ME201/MTH281 F2002), a surface visit to Glia-6 was not possible because of a continuing dust storm. The Academy cadets on board the orbiting Enterprise engaged in the design of a stealth submarine, using the novel technique of flow into and out of the submarine to mask the more prominent components of the far field. On the tenth visit to the Glia starsystem (Stardate 9966.2, ME201/MTH281 F2003), the Cadets were charged with explaining why there was a melt down of a nuclear reactor long ago in the abandoned Platonian colony on Glia-6. Significant new information on the reactor was available in a recently discovered manual in the historical repository opened several years ago by Cadets. The manual describes a unique