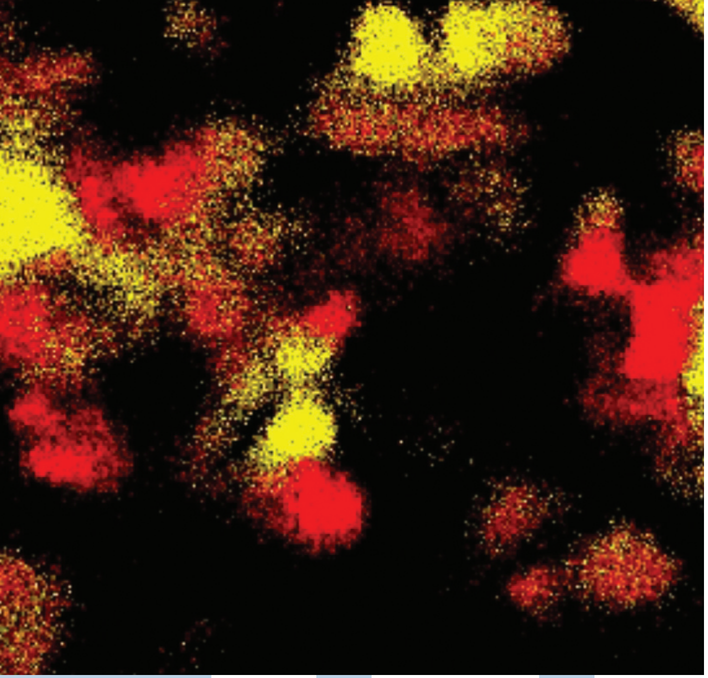

Think

Chaotically

The Physics of Complexity

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Understanding **complexity** is one of the central pursuits in physics today. Complexity encompasses such diverse things as the weather and earthquakes, how living organisms solve problems, how traders create economic markets, and many other interesting phenomena, including those in this brochure.

Traditionally, physicists have assumed that the characteristics of a system can be fully understood by knowing everything about how the pieces of the system work. Complex systems challenge that assumption, however. In them, the behavior of the whole is often surprising and seemingly unrelated to the behavior of the pieces. As a consequence, understanding and harnessing complexity requires new ways of thinking, new experimental procedures, and new tools—including, for example, "fractals" and "chaos."

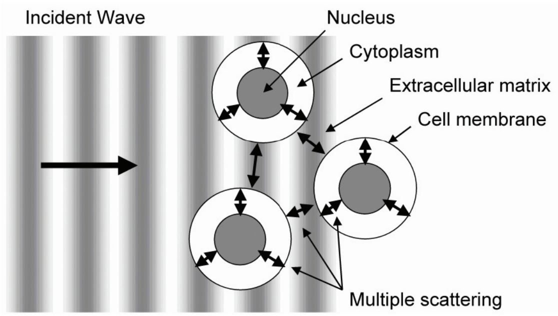
Complexity science at USU is a highly interdisciplinary enterprise involving undergraduate and graduate students and faculty in physics, biology, computer science, mathematics, and engineering, as well as colleagues at other institutions.

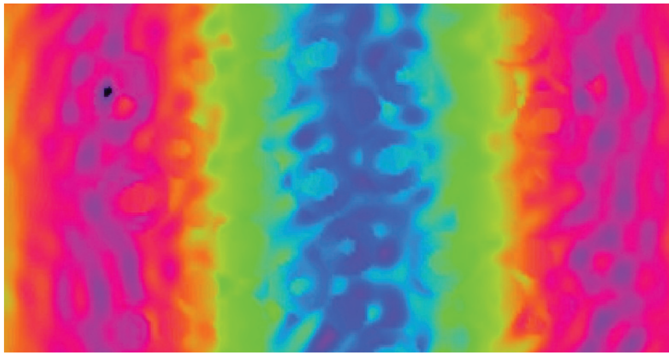
Support for students in complexity science at USU has come from the National Science Foundation and private industry.

The many projects currently under study include:

Medical Ultrasound

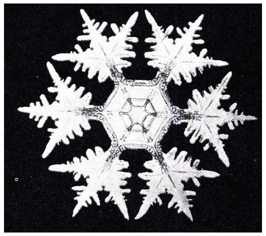
By understanding how ultrasound interacts with tissues at the microscopic level, non-invasive methods can be developed to detect and treat cancer and other illnesses at an earlier stage in their development.





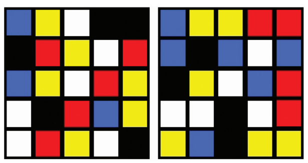
Computer simulation of ultrasonic waves in cells and tissues, showing the effects of complex microscopic structures.

Did You Know?



- Fractals are things that look like themselves at different levels of magnification?

- Chaos is a process in which future outcomes are completely determined by the past, yet, because of their irregular variations, appears to be random—that is, without rhyme or reason. One difference between chaos and random is that in chaos the outcomes make little patterns that try to repeat over-and-over. So here's a quiz: which of the checkerboards below is random and which comes from chaos? (The checkerboards are filled in top to bottom and left to right, one by selecting the colors at random, the other by selecting them using chaos.)



Interested?

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Advanced Composites

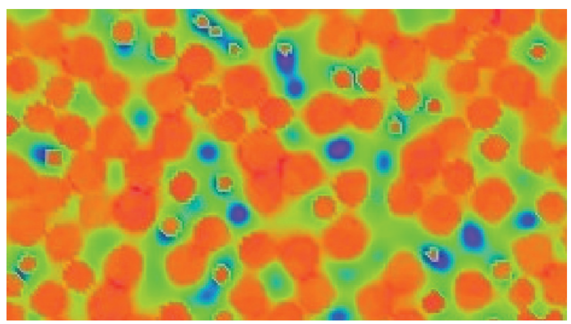
The modeling of ultrasonic wave propagation in random particle-filled materials is being applied to the development of new nondestructive evaluation methods for advanced composites.

Atmospheric Airglow Tomography

Tomography methods are being developed for the 3-D imaging of dynamic processes in the upper atmosphere, important to understanding the global atmospheric environment.

Soil Physics

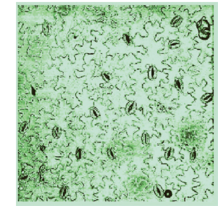
Models are being developed to predict the electromagnetic properties of soils to provide a more fundamental understanding of soils and their remote sensing at the microscopic level.



Electric field distribution in a simulated soil (fractal-like packing of glass spheres).

Answer to quiz: left is chaos, right is random

Information Processing in Plants



Plants take in carbon dioxide from the air for photosynthesis by opening pores on the surfaces of their leaves. In doing so, they also lose water. Thus, a plant has to solve a cost-benefit problem: "how open should I make my pores so that I get the most CO^2 possible while losing the least amount of water?" Surprisingly, in solving this problem the plant's pores act in patchy synchrony, with many opening together and many others closing together. This is shown in the black, red, and yellow picture above "THINK" on the first panel of this brochure. As time goes on these patches move about the leaf much the way patches of electrical activity move about the brain when a person thinks. The physics of how pores on a leaf "solve problems" is being investigated experimentally and theoretically. These studies are being applied to understanding information processing in the immune system and how to create artificial computational networks that, like plants, can thrive in hostile environments.