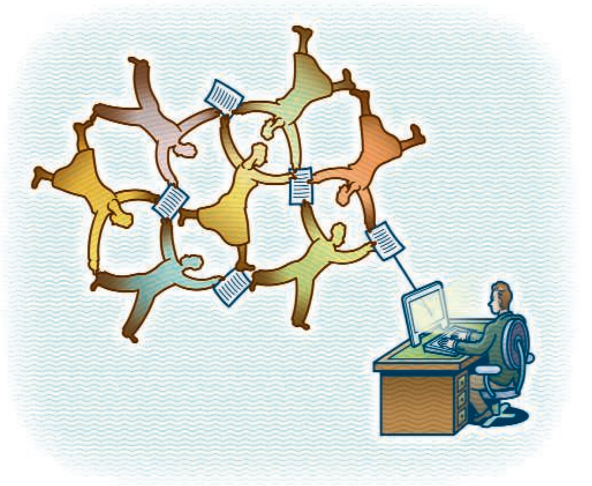
COMPUTER SCIENCE

Weaving a Web of Trust

Analysis of online social networks may provide a metric for establishing trust in user-generated content.

Jennifer Golbeck

Increasingly, people are studying social and collaborative Web technologies for use in science (*1*, *2*). However, issues such as privacy, confidentiality, and trust arise around the use of these technologies. Science is crucially based on knowing provenance—who produced what, how and where—and on the Web, trusting scientific information is becoming more difficult for both scientists and the general public. User-generated content, even from professionals, can be opinionated (both informed and uninformed), inaccurate, and deceiving. With an overwhelming amount of information of questionable origin and reliability, finding trusted information created by trusted people is the new challenge. The use of social trust relationships for this task is both practical and necessary as the Web evolves.



Got it…with a little help from my "trusted" friends.

The term "trust" has traditionally been used in a security context, referring to authentication, identity, and authorization. Advances in these areas have been critical for the Web to evolve as it has. However, with the increase in user-generated content, a new type of trust is needed. Social trust relationships capture similarity in perspective. Sociological definitions of trust generally have two major components: a belief and a willingness to take some action based on that belief (*3*, *4*). Although this type of trust is often unsuitable for critical security applications, it has other uses that are leading it to become more important. In the context of the Web, trust translates to belief that an information producer will create useful information, plus a willingness to commit some time to reading and processing it. Thus, if users can identify the information producers they trust online, then they can spend their time more effectively by working with information from them.

Research has shown that trust is a good metric for identifying useful content; trust reflects similarity in opinions both overall (*5*) and in nuanced ways that are especially important. Further experiments have shown that filtering information based on trust is particularly effective when the user's opinion differs from that of the average population (*6*). Essentially, when users most need information based on their viewpoint, using social trust can provide it.

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The most important challenge to using social trust in this way is estimating how much one user will trust another. With hundreds of millions of users on the Web, it is extremely unlikely that any two will know one another. There are hundreds of online social networks with more than a billion accounts among them. This wealth of publicly available social relationships offers one mechanism for estimating trust between users. A number of algorithms exist for computing trust from social networks (*7*–*10*) that rely on the network structure or similarity measures between users. However, these algorithms have only just begun to explore the space of understanding the dynamics of trust and trying to compute it. Techniques from machine learning and probabilistic reasoning could be used to create better algorithms for trust inference. The complex systems approaches to understanding network structure (*11*) and dynamics and discovering community structure (*12*) also hold promise.

Once established, the benefits of trust come from using it in applications. For the scientific community, trust can add context to content, using it to rate, sort, and filter information. The benefits of trust have been shown through several more general applications. Recommender systems, which suggest items to users on the basis of user profiles, are popular and have been successful for topics as diverse as movies (*6*) and ski routes (*7*). E-mail, where the trust that the recipient has in the sender is used to rank messages (*13*), is another application. Peer-to-peer systems have also used trust from social networks to improve routing by relying on peers controlled by trusted people (*14*).

These applications have been evaluated and shown to improve the way people access user-generated content. However, there is much work to be done in this area. The most critical is identifying sources of trusted information. Although we have algorithms that work well on social networks where users rate the trustworthiness of their peers, this sensitive information is never publicly shared, making it difficult for third-party applications to make use of that trust. More mechanisms are needed that can infer trust accurately from less sensitive sources. Further development is also necessary to understand the circumstances where trust offers the most benefit. In current research, trust-based applications never perform worse than simpler counterparts, but they do not always perform appreciably better. We have some initial insights into when trust works best, but a more systematic understanding will improve when and how we use it.

Social trust relationships may transform the way scientists, and the general public, use the Web. Over the past 5 years, research has shown the practicality of computing social trust and the benefits of using it. As the amount of user-generated content increases, the need for this social approach to information filtering also grows. The success of trust-based methods depends on additional research to identify where they offer the most benefit, as well as an understanding that social trust is needed on the Web as much as it is in the real world.

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DEVELOPMENTAL BIOLOGY

Apoptosis Turbocharges Epithelial Morphogenesis

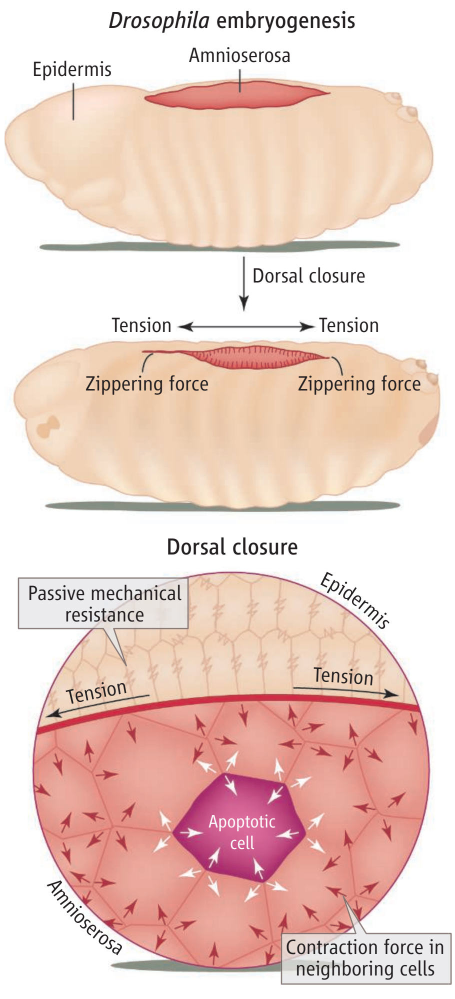
Mechanical forces that contribute to tissue movement during animal morphogenesis may include those generated by cell death during development.

Lance A. Davidson

Programmed cell death, or apoptosis, occurs throughout animal development. In the fruit fly *Drosophlia melanogaster*, apoptosis occurs in distinctly restricted patterns as tissues and organs form (*1*). First thought to play a role in eliminating malformed cells during embryogenesis, flies with mutations in apoptosis genes showed lethal phenotypes (*2*). Although the role of apoptosis during early stages of morphogenesis appeared critical, the reasons were not clear. On page 1683, in this issue, Toyama *et al*. (*3*) reveal that programmed cell death contributes to the mechanical forces that drive cell movements and cell shape changes during epithelial morphogenesis in the *Drosophila* embryo to construct the free-living larva.

The early embryo establishes the larval body plan, protecting internal organs and muscles within a tough epidermis. Once gastrulation has positioned mesoderm and endoderm, a process called dorsal closure completes the body plan by sealing yolk and the amnioserosa, the last of extraembryonic tissues, within the epidermis (see the figure). At the start of dorsal closure, the amnioserosa and dorsal epidermis are adjacent to each other, forming a cohesive epithelial sheet of cells tightly connected by junctions along their outer apical surface.

Multiple forces drive dorsal closure as the dorsal epidermis spreads and amnioserosal cells constrict. These opposing changes in surface areas ensure closure. Through a detailed biomechanical analysis that combines high-resolution imaging and cell and genetic manipulation, Toyama *et al*. find that apoptosis contributes between half and a third of the forces needed to seal the dorsal epithelium over the embryo. Their study is the most recent example of quantitative analyses of morphogenesis in *Drosophila*, addressing questions on the physical mechanics of dorsal closure (*4*), elongation of the germ band (comprising multiple germ layers on the ventral side of the embryo that curves around the embryo) (*5*, *6*), cell shape changes in the ommatidia during compound eye development (*7*), as well as the origin of epithelial architecture (*8*) and maintenance during wing differentiation (*9*).



The sum of forces. A schematic of dorsal closure in the *Drosophila* embryo. Multiple forces contribute to, and resist, closure.

Epithelial morphogenesis is the sum of a variety of cellular and mechanical processes, but how do they integrate with each other? For the actions of cells on one side of the embryo to contribute to movements on the other, forces generated at one side must be transmitted through physical connections between cells to move tissues on the other side. Forces may originate from a single source or from multiple locations, but the tissue movements are in response to the sum of vector forces from these multiple locations. The challenge is to distinguish between forces that are due to nonautonomous macroscopic phenomena like germ-band retraction, or autonomous processes, such as contraction of the apical regions of cells within the amnioserosa, or the removal of apoptotic cells from particular locations, as they contract their exposed surface and move into the embryo. Resolving this "vector sum" into constituent forces will help to determine how specific cellular and molecular processes contribute to dorsal closure.

Unlike complex three-dimensional cases of epithelial morphogenesis that involve bending or rolling an epithelial sheet of cells into a tube, the two-dimensional mechanics within the plane of a sheet of epithelial cells makes dorsal closure more tractable and appealing to theoreticians and physicists. In previous work (*4*), the group behind the current study revealed the relative forces driving dorsal closure and their tissue origins. Using laser microdissection, they cut slits in the

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