Neutron Star Measurements

Neutron stars are one of the densest manifestations of matter in the universe. Yagi and Yunes (p. 365) examined the moment of inertia of neutron stars, which determines how fast they can spin, and the quadrupole moment and tidal Love number, which determine how much they can be deformed. The findings suggest that these three quantities obey universal relationships that are independent of the internal structure of the stars, implying that measurements of one of the three could accurately predict the other two.

Holographic Turbulence

Turbulence in a superfluid presents an even more challenging theoretical problem than classical turbulence. Chesler et al. (p. 368) studied simulated superfluid turbulence using holographic duality. The direction of the energy flow in a two-dimensional superfluid was opposite to that in classical fluids—the energy injected at long length scales dissipated at short length scales through the vortices that form in a turbulent superfluid.

Rust Resistance

The rusting of iron and steel can be prevented through the addition of 11% or more chromium. The addition of molybdenum can enhance the corrosion resistance, with a complex interplay between the Cr and Mo atoms. However, if chemical variations exist, corrosion can still occur in localized regions or if the surface layer is mechanically abraded. Duarte et al. (p. 372) studied the corrosive failure of an iron-based glassy alloy. A combination of atom probe tomography, electron microscopy, and x-ray diffraction was used to build up a near atomistic picture of local variations in the metal as it was heated and allowed to crystallize, and the impact these processes have on the corrosion resistance.

Sweet Variety

Proteins fold into a great variety of shapes—but, topologically, they always start as a more or less straight line of linked amino acids. In contrast, carbohydrates manifest a range of structures in which the sugar building blocks connect through multiple branch points. Wang et al. (p. 379, published online 26 July; see the Perspective by Kiessling and Kraft) designed a versatile precursor that could be transformed into many different branched glycans with distinct building blocks along each branch.

Can You Trust Your Memory?

Being highly imaginative animals, humans constantly recall past experiences. These internally generated stimuli sometimes get associated with concurrent external stimuli, which can lead to the formation of false memories. Ramirez et al. (p. 387; see the cover) identified a population of cells in the dentate gyrus of the mouse hippocampus that encoded a particular context and were able to generate a false memory and study its neural and behavioral interactions with true memories. Optogenetic reactivation of memory engram–bearing cells was not only sufficient for the behavioral recall of that memory, but could also serve as a conditioned stimulus for the formation of an associative memory.

PTEN Variations

The product of the tumor suppressor gene phosphate and tensin homolog on chromosome ten (PTEN) is a lipid and protein phosphatase that regulates important cellular processes, including growth, survival, and metabolism (see the Perspective by Leslie and Brunton). Though PTEN is best known for effects on the phosphatidylinositol 3-kinase (PI3K) signaling pathway, the PTEN protein is also found in the nucleus. Bassi et al. (p. 395) found that PTEN’s presence in the nucleus was regulated in response to covalent modification of the protein by SUMOylation and phosphorylation. Cells lacking nuclear PTEN showed increased sensitivity to DNA damage and underwent cell death if the PI3K pathway was also inhibited. Hopkins et al. (p. 399, published online 6 June) discovered an alternative translation start site in human PTEN messenger RNA that allowed expression of a protein, PTEN-Long, with about 170 extra amino acids. The unusual enzyme was released from cells and then taken up into other cells. In a mouse tumor model, uptake of the enzyme inhibited the PI3K pathway and inhibited tumor growth.

A Gene for Early Acceptance

One of the fundamental properties of the immune system is the ability to distinguish self- from nonself–histocompatibility. To gain insight into the evolution and molecular basis of histocompatibility, Voskoboynik et al. (p. 384) sought to determine the genetic basis for a natural transplantation reaction that occurs in Botryllus schlosseri, a colonial urochordate. Compatibility allows vascular fusion among individuals, whereas incompatibility results in an inflammatory rejection response. A single gene determined the outcome of the reaction. Like histocompatibility genes in higher organisms, this gene is polymorphic and is expressed in the tissues that participate in the transplantation reaction.
Infectious Information?

Much of the recent work on how individuals in social networks behave has relied upon the established Susceptible, Infectious, Recovered model developed in epidemiology. Information, however, differs from disease in one respect, namely that an individual might acquire information and yet not use it (or become “infected” by it). Banerjee et al. (p. 363) examined the spread of information about microfinance and its adoption in 43 villages in Karnataka, a state in southern India. Adopters of microfinance were more likely to pass information about it on, and a new measure—diffusion centrality—of the first person to learn new information predicted how widely and quickly others would be likely to make use of it.

Not mTORCing

Inhibition of the protein kinase complex mTORC1 has potentially beneficial therapeutic affects that include inhibition of cancer and extension of life span. However, effects of its inhibition in vivo have sometimes been disappointing. One reason may be that the well-studied inhibitor of mTORC1, rapamycin, inhibits some effects of mTORC1 but not others. In line with this idea, Kang et al. (p. 364) show that the effect of rapamycin depends on the substrate. Characteristics of the phosphorylation sites on various substrates caused them to be phosphorylated with different efficiency by mTORC1. The substrates that were most efficiently phosphorylated were resistant to inhibition of mTORC1. The results explain how various sites, sometimes within the same protein, can differ in their sensitivity to rapamycin.

Order, Order

The structure of glassy materials, which are known to have short-range order but no long-range pattern, continues to be a puzzle. One current theory is that some glassy materials possess icosahedral ordering, a motif that cannot show translational periodicity. Hirata et al. (p. 376, published online 11 July) obtained diffraction patterns from subnanometer volumes in a metallic glass, which show some, but not all, of the expected features of an icosahedron. Simulations suggest that the patterns arise from icosahedrons distorted to include features of the face-centered cubic structure. This observation is different from the predictions of molecular dynamics simulations and provides pivotal information in understanding the competition between the formation of the globally inexpensive long-range order and the locally inexpensive short-range order.

In a FtsZ

FtsZ is a guanosine triphosphatase that polymerizes into protofilaments at the bacterial division site. FtsZ recruits the accessory division proteins to the septum and also provides mechanical forces needed to constrict the membrane and reduce the cell width. However, how FtsZ generates mechanical force is unclear. While one popular model suggests that mechanical forces are generated by means of a change in FtsZ structure induced by guanosine triphosphate hydrolysis, nucleotide-dependent conformational transitions have yet to be observed in FtsZ monomer structures. Such transitions may be a feature of FtsZ only in its native protofilament-forming state. Li et al. (p. 392) sought to resolve this question by obtaining high-resolution structures of guanosine diphosphate–bound FtsZ filaments. The results suggest a complex and dynamic FtsZ protofilament network with a high degree of plasticity that is capable of generating forces to drive cytokinesis, during cycles of hydrolysis, while maintaining the structural integrity of individual monomers.

Whence the “Eat Me” Signal?

Cells are surrounded by a lipid bilayer, the composition of which is asymmetrical and serves as a marker of the physiological status of the cell. The phospholipid, phosphatidylserine (PtdSer), is normally found only on the inner leaflet of the membrane, but in dying cells it appears on the cell surface, thus providing the phagocytes tasked with cleaning up such cellular debris with a way to recognize cells undergoing cell death. Such movement of phospholipids within the membrane requires an elusive enzyme known as a scramblase. Suzuki et al. (p. 403; published online 11 July) identified an enzyme, Xkr8, which appears to act as a scramblase that promotes exposure of PtdSer on the surface of dying mammalian cells. Consistent with such a role, Xkr8 was activated after cleavage by caspase 3, a key protease that promotes apoptotic cell death. Genetic studies with the homolog of Xkr8 expressed in Caenorhabditis elegans indicated that the protein played a similar role in tagging dead cells in the nematode worm during development.

H7N9 Adaptation

Puzzling and alarming reports of an outbreak in early 2013 of human infections by a low-pathogenicity avian influenza virus has rocked the poultry industry in central eastern China and brought fears of initiating a human pandemic. Over 130 human cases have been reported with 37 deaths until closure of poultry markets accompanied a near-cessation of human case reports. From surveillance sampling of >10,000 isolates obtained during April 2013, Zhang et al. (p. 410, published online 18 July) took 37 isolates of avian origin H7N9 and compared them to human H7N9 isolates. The majority of H7N9 isolates came from live poultry markets, although some originated in pigeons. Sequence analysis indicated that the chicken isolates had retained the avian characteristics at sites on the influenza genes for PB2 and the surface hemagglutinin HA, where adaptive mutations have been observed before. Sequence analysis also showed a higher variability in the internal genes than in HA and neuraminidase NA. By using glycan arrays, it was shown that avian and human isolates bound to human, but also to some extent to avian, receptors. As expected, the virus replicated well in chickens without causing disease, whereas in mice only the human isolates were highly pathogenic. The human virus, but not the avian, transmitted between ferrets through the air.