more access to drug, or if exposed to, for example, stress or different environments? How does extended access to cocaine change the brain (and only in susceptible individuals) to produce different symptoms of addiction? In providing more realistic preclinical animal models of addiction than previously available, the two new reports set the stage for developing exciting new approaches with which to unravel the psychology and neurobiology of addiction.

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CLIMATE SCIENCE

Already the Day After Tomorrow?

Bogi Hansen, Svein Østerhus, Detlef Quadfasel, William Turrell

With even Hollywood aroused, the thermohaline circulation (THC) of the ocean has become a public theme, and not without reason. The THC helps drive the ocean currents around the globe and is important to the world's climate (see map on this page). There is a possibility that the North Atlantic THC may weaken substantially during this century, and this would have unpleasant effects on our climate—not a disaster-movie ice age, but perhaps a cooling over parts of northern Europe.

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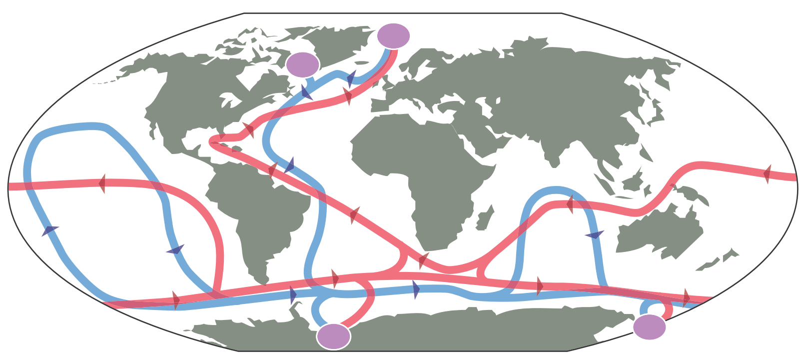
The THC is a driving mechanism for ocean currents. Cooling and ice formation at high latitudes increase the density of surface waters sufficiently to cause them to sink. Several different processes are involved, which collectively are termed "ventilation." When active, ventilation maintains a persistent supply of dense waters to the deep high-latitude oceans. At low latitudes, in contrast, vertical mixing heats the deep water and reduces its density. Together, high-latitude ventilation and low-latitude mixing build up horizontal density differences in the deep ocean, which generate forces. In the North Atlantic, these forces help drive the North Atlantic Deep Water (NADW) that supplies a large part of the deep waters of the world ocean.

Not everybody agrees that the THC is an important driving mechanism for the NADW flow. The north-south density differences observed at depth might be generated by the flow rather than driving it (*1*). This argument is tempting, but it neglects some salient features of the real ocean that are at odds with many conceptual, analytical, and even some numerical models.

The Greenland-Scotland Ridge splits the North Atlantic into two basins (see the figure on the next page). Most of the ventilation occurs in the northern basin, and the cold dense waters pass southward as deep overflows across the Ridge. According to measurements (*2–4*), the total volume transport across the Ridge attributable to these overflows is only about one-third of the total NADW production, but the volume transported approximately doubles by entrainment of ambient water within just a few hundreds of kilometers after passing the Ridge.



Thermohaline circulation. Schematic map of the thermohaline circulation of the world ocean. Purple ovals indicate ventilation areas, which feed the flow of deep dense waters (blue lines with arrows). These waters flow into all of the oceans and slowly ascend throughout them. From there, they return to the ventilation areas as warm compensating currents (red lines with arrows) in the upper layers.

On their way toward the Ridge, the overflow waters accelerate to current speeds of more than 1 m/s, which is clear evidence of THC forcing. After crossing the Ridge, the flows descend to great depths in bottom currents, which again are density-driven. In the present-day ocean, THC drives the overflows, which together with the entrained water feed most of the NADW.

This is the reason why people worry about a possible weakening of the THC. In the coming decades, global change via atmospheric pathways is expected to increase the freshwater supply to the Arctic. This will reduce the salinity and hence the density of surface waters, and thereby may reduce ventilation. Even if the ventilation comes to a total halt, this will not stop the overflows immediately, because the reservoir of dense water north of the Ridge stabilizes the overflow. Instead, the supply of NADW would diminish in a matter of decades. In contrast, large changes in low-latitude mixing—even if conceivable—require a much longer time before affecting the THC (*5*).

A potential weakening of the North Atlantic THC would affect the deep waters of the world ocean in the long run, but would have more immediate effects on the climate in some regions. The dense overflow waters feeding the deep Atlantic are replenished by a compensating northward flow in the upper layers. These currents bring warm saline water northward to the regions where ventilation and entrainment occur. This oceanic heat transport keeps large Arctic areas free of ice and parts of the North Atlantic several degrees warmer than they would otherwise have been (*6*).

A substantially weakened THC reduces this heat transport and regionally counterbalances global warming. In some areas, it might even lead to cooling (*7*). This has in-

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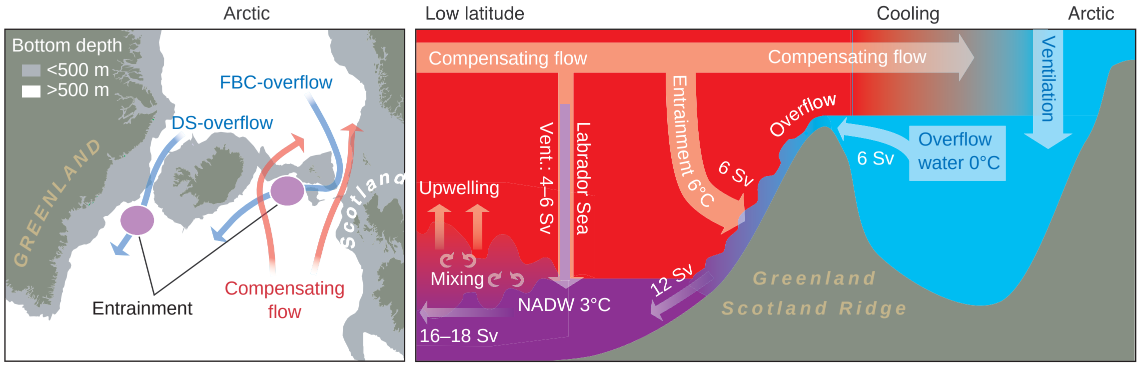

North Atlantic flow. The exchange of water across the Greenland-Scotland Ridge is a fundamental component of the North Atlantic THC. Arrows on the map indicate the main overflow (blue) and compensating inflow (red) branches. On the schematic section to the right, temperatures in °C and volume transports in Sv (1 Sv = 10^6 m^3/s) are approximate values. DS, Denmark Strait; FBC, Faroe Bank Channel.

spired a public debate focused on a potential cooling of northern Europe, which has the compensating flow just off the coast. Note that this part of the North Atlantic THC is especially dependent on ventilation north of the Greenland-Scotland Ridge, overflow, and entrainment (*3*).

The concept of a weakened THC is supported by some numerical climate models (*8*), but not by all. Increased salinity of the compensating flow may balance the salinity decrease from the increased freshwater supply and maintain ventilation (*9*). Climate models, so far, do not provide a unique answer describing the future development of the THC, but what is the present observational evidence?

It is argued that early evidence for changes should primarily be sought in the ventilation and overflow rates. Indeed, some such changes have been reported. Since around 1960, large parts of the open sea areas north of the Greenland-Scotland Ridge have freshened (*10*), and so have the overflows (*11*). At the same time, low-latitude Atlantic waters became more saline in the upper layer (*12*), and this is also reflected in the compensating flow. Long-term observations in both of the main branches of compensating flow across the Greenland-Scotland Ridge have shown increasing salinity since the mid-1970s, with a record high in 2003.

Even more convincing evidence for a reduction of the North Atlantic THC has been gained from monitoring both the overflows and the compensating northward flow by direct current measurements (*13*). For the Denmark Strait overflow, no persistent long-term trends in volume transport have been reported (*2*, *14*), but the Faroe Bank Channel overflow was found to have decreased by about 20% from 1950 to 2000 (*15*).

We find evidence of freshening of the Nordic Seas and a reduction of the strength of the overflow, both of which will tend to weaken the North Atlantic THC. On the other hand, the compensating northward flow is getting more saline, which may maintain ventilation and counterbalance the THC decrease. So the jury is still out. This emphasizes the need for more refined climate models and long-term observational systems that are capable of identifying potential changes in our climate system.

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NEUROSCIENCE

NAD to the Rescue

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The cofactor nicotinamide adenine dinucleotide (NAD)—once consigned to the oblivion of metabolic pathway wall charts—has recently attained celebrity status as the link between metabolic activity, cellular resistance to stress or injury, and longevity. NAD influences many cell fate decisions—for example, NAD-dependent enzymes such as poly (ADP-ribose) polymerase (PARP) are important for the DNA damage response, and NAD-dependent protein deacetylases (Sirtuins) are involved in transcriptional regulation, the stress response, and cellular differentiation. On page 1010 of this issue, Araki and colleagues (*1*) extend the influence of NAD with their demonstration that an increase in NAD biosynthesis or enhanced activity of the NAD-dependent deacetylase SIRT1 protects mouse neurons from mechanical or chemical injury (*2*).

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Axonal degeneration (termed Wallerian degeneration) often precedes the death of neuronal cell bodies in neurodegenerative diseases such as Alzheimer's (AD) and Parkinson's (PD). Mice carrying the spontaneous dominant *Wld^s^* mutation show delayed axonal degeneration following neuronal injury. The *Wld^s^* mutation on mouse chromosome 4 is a rare tandem triplication of an 85-kb DNA fragment that harbors a translocation. The translocation encodes a fusion protein comprising the amino-terminal 70 amino acids of Ufd2a (ubiquitin fusion degradation protein 2a), an E4 ubiquitin ligase, and the entire coding region of Nmnat1 (nicotinamide mononucleotide adenylyltranferase 1), an NAD biosynthetic enzyme. Although the C57BL/*Wld^s^* mouse was described 15 years ago (*3*) and expression of the Wld^s^ fusion protein is known to delay Wallerian degeneration (*4*), the mechanism of neuroprotection has remained elusive. Given that proteasome inhibitors block Wallerian degeneration both in vitro and in vivo (*5*), the Ufd2a protein fragment (a component of the ubiquitin proteasome system) has been the prime candidate for mediator of neuroprotection in the *Wld^s^* mouse. Indeed, ubiquitin-mediated protein degradation by the proteasome