of about 80 M_J for ignition of hydrogen fusion. Stars that fall within the 10 to 80 M_J range are thus known as brown dwarfs — massive enough to have been formed in the same way as other stars, but too lightweight to shine as brightly or for very long.

The brown dwarfs that have been discovered previously all have masses that fall within the expected range of 10 to 80 M_J. PPl15 has a mass[5] of about 60 M_J, while both Teide 1 and Gl229B have masses[6,7] in the range 20 to 50 M_J. These masses are estimated using theoretical models of brown dwarf thermal evolution, observed luminosities and ages inferred for either the primary star or the stellar cluster they reside in. HD114762 has a companion[8] detected in a similar way to the new objects, with a lower limit on its mass of 11 M_J, but in this case there is evidence that the orbit is viewed nearly pole-on[9] so the mass is likely to be much greater than 11 M_J.

Thus, before the January meeting, there was a fairly wide gap between the mass of the smallest known brown dwarfs and that of the most massive planets observed or believed to be possible. The objects found by Marcy and Butler, with masses of about 3 to 8 M_J, sit right inside the gap, making it harder to use mass alone as a clear discriminator between giant planets and brown dwarfs.

However, there is another key discriminator between stellar and planetary origins: the orbital eccentricity (at least for companions at large enough distances to avoid having their orbits made circular by tidal dissipation). Normal, main-sequence binary stars are known to form with eccentric orbits[10]. This eccentricity is believed to be a result of the process that forms binary stars: a rapidly collapsing cloud, far from equilibrium, breaks up into two fragments moving on elliptical orbits. In contrast, major planets form with nearly circular orbits, reflecting their origin in the more ordered environment of a dissipative protoplanetary disk, which will have settled into keplerian rotation. The fact that 51 Peg B and 47 UMa B have circular orbits speaks strongly for their planetary nature, whereas the eccentricities of 70 Vir B and HD114762B imply their stellar origin.

In analogy to close binary stars, brown dwarf companions should be able to form with rather small separations, but the proximity (0.05 AU) of 51 Peg B to its star presents a problem if it formed as a planet. A giant planet cannot form closer than a few AU from its star because the icy planetesimals required for its formation are not stable in the hot inner disk[11]. By this measure, 51 Peg B should not be there unless it is actually a brown dwarf. The problem can be solved by allowing 51 Peg B to form as a giant planet at several AU and then migrate inwards through its gravitational interactions with the disk[12]. The location of 47 UMa B at 2.1 AU requires little or no orbital migration.

The spectroscopic method favours the detection of massive companions with small separations (see figure), but patience will surely result in the discovery of extrasolar Jupiters and Saturns at greater separations than a few AU, which would imply the existence of planetary systems similar to our own. At the January meeting, Daniel Goldin (Administrator of the National Aeronautics and Space Administration) committed NASA to a long-term programme of extrasolar planet detection. NASA's future results should be even more stunning. □

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MEDICAL GENETICS

Crystal-clear chloride channels

Steven C. Hebert

KIDNEY-STONE disease (nephrolithiasis) occurs worldwide, often causing excruciating pain and infection of the urinary tract and leading to loss of kidney function[1,2]. The offending stones are typically composed of calcium salts that precipitate out of urine supersaturated with calcium (hypercalciuria)[2]. This hypercalciuric nephrolithiasis is frequently inherited as a fault on the X chromosome[3] and one type, Dent's disease, has been pinpointed in one family by Thakker and co-workers[3,4] to a defect in a gene, dubbed *CLCN5*, that encodes a putative chloride channel, CLC-5.

This was quite a surprise because Dent's disease was considered to be a dysfunction in the transport of renal calcium and not apparently of chloride or fluid volume. On page 445 of this issue, Thakker and colleagues[5] now extend their discovery of a chloride 'channelopathy' in more families with Dent's disease by identifying new mutations in the *CLCN5* gene. They also find that two other types of hypercalciuric nephrolithiasis, which map to the same defective region on the X chromosome as Dent's disease (X-linked recessive nephrolithiasis and recessive hypophosphataemic rickets), are associated with mutations in this same chloride channel which are responsible for inactivating it. This not only provides compelling evidence for an important function of the CLC-5 chloride channel in the renal tubule handling of calcium, but also poses the possibility that abnormal function of this channel may be involved in some other forms of hypercalciuric nephrolithiasis.

CLC-5 belongs to a growing family of chloride channels with twelve putative membrane-spanning helices[6]. The first member, CLC-0, was cloned from the electric organ of the *Torpedo* ray by Jentsch and co-workers[7]. Some CLC chloride channels are widely expressed, for example CLC-2, which is involved in the regulation of cell volume. Others are tissue-specific, such as CLC-1 in muscle (mutations in CLC-1 cause dominant myotonia congenita) or the kidney-specific CLC-K1 or K2 channels, which may mediate epithelial chloride absorption. CLC-5 is most closely related, however, to the CLC-3 (rat) and CLC-4 (human) type channels, but unlike these channels, which have a broad tissue distribution, both rat[8] and human[3] CLC-5 channels are expressed predominantly in kidney.

A central question now is how loss of the function of this renal chloride channel can result in hypercalciuria, as well as in the other characteristic tubule transport defects. In the nephron, the functional unit of the kidney, ionized calcium is freely filtered out of the blood plasma, along with waste products destined for excretion, at the glomerulus and into the proximal tubule, where it is reabsorbed as necessary or otherwise passed into the distal tubule for excretion. This carefully controlled process goes wrong in hypercalciuria as a result of defective reabsorption of the divalent cation.

Although no information is currently available as to which specific epithelial segments of the nephron express CLC-5 channels, the presence of small proteins in the urine of patients with Dent's disease points to some problem with the tubules, probably involving, at a minimum, the proximal tubule segments. Most proteins are too large to be filtered at the glomerulus, but small proteins like β_2-microglobulin can get through and are normally reabsorbed in this region of the nephron. Other indicators of damage to the proximal tubules (for example, the presence of

amino acids, uric acid or glucose in the urine) are also found in some patients with X-linked recessive nephrolithiasis[9].

About 70–80 per cent of the filtered calcium is reabsorbed in the proximal tubule in a largely passive process that is dependent on solvent drag associated with bulk fluid reabsorption[10], which in turn is dependent on reabsorption of active solute, including chloride. One possibility is that CLC-5 channels in the proximal tubule are involved in transepithelial chloride transport; loss of this channel would result in diminished reabsorption of chloride and fluid and consequently of calcium. But how such a mechanism could account for the presence of low-molecular-weight proteins in the urine is not clear.

CLC-5 chloride channels, like a number of other types of ion channels, appear to form multimeric complexes[6,11] which might not only influence the biophysical properties of CLC-5-containing complexes, as suggested by Thakker and colleagues, but could also permit the association of CLC-5 with other subunits, expanding the repertoire of possible physiological roles for this channel. For example, low-molecular-weight proteins that are specifically absorbed in the proximal tubule are taken up by endocytosis into a vacuolar-lysosomal system with an acidic interior provided by the action of an electrogenic H^+-ATPase pump[12]. Chloride channels are important in such vesicular systems because they provide a mechanism for dissipating the charge that results from proton pumping.

Perhaps CLC-5 channels play some part in this process. Could the disrupted movement of these vesicles within the cell affect the function of the transporters for calcium (and maybe those for phosphate or amino acids) in renal tubule plasma membranes, and therefore the absorption of these solutes? Or could CLC-5 channels also be involved in the control of calcium transport in more distal segments of the human nephron? Regulated calcium absorption occurs in these more distal nephron segments and divalent mineral ion absorption is strongly dependent upon, or influenced by, chloride transport processes[10]. The possible participation of CLC-5 in these processes needs to be explored.

Another big question to emerge from the new work[5] concerns the differences found among these three hereditary hypercalciuric disorders in bone pathology (rickets) and in the amount of deposition of calcium salts in the kidney. There is no obvious correlation between the phenotypic differences and the type of *CLCN5* mutation, but the limited number of mutations studied may have obscured such an association. Could *CLCN5* actually be expressed in bone cells and thus contribute to bone abnormalities? Perhaps other genetic or environmental factors, such as calcium or phosphate intake, dietary vitamin D, or circulating levels of parathyroid hormone, may influence the severity of bone and renal pathology in these patients.

Once the localization, function and regulation of CLC-5 are known, we should have a clearer picture of how this chloride channel functions in the kidney. But there may be more surprises in store. □

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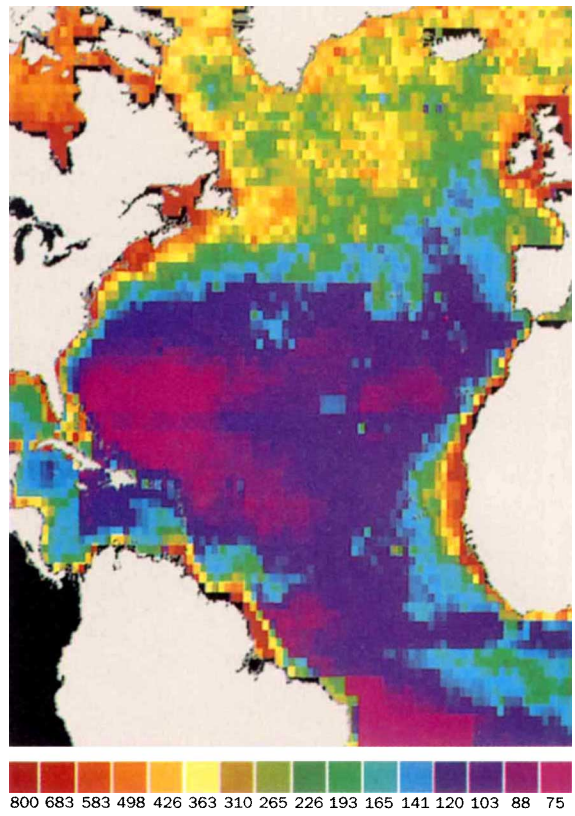
BIOLOGICAL OCEANOGRAPHY

Provincial primary production



Is this picture just another ocean-colour satellite image of the North Atlantic? Not at all. S. Sathyendranath *et al.* have exploited the remote-sensing revolution — which transformed marine science with ocean-colour measurements made using a trial sensor between 1978 and 1986 — by calculating the biological productivity of the entire North Atlantic at a regional resolution and by season (*Deep-Sea Res. I*, 42, 1773–1802; 1995). The picture shows the estimated annually averaged primary production in 1979, the year with the best total data set (units are g carbon m^{-2}).

The authors went about their task by first devising a scheme for dividing the ocean up into 18 different 'biogeochemical provinces' according to observed algal ecology and physical processes such as vertical mixing — these provinces are akin to different terrestrial biomes, boreal forest, savanna, desert and tundra for instance. They then used thousands of *in situ* measurements of photosynthetic parameters and vertical distributions of chlorophyll, combined with phytoplankton pigment data derived from the satellite observations, to compute primary production for different seasons for each biogeochemical province. Despite the patchiness of the satellite data, these are the most robust regionally resolved estimates yet made of marine primary productivity on a basin-wide scale. Such estimates are of great value not only to ecophysiologists, but — given the involvement of marine ecosystems in the global carbon cycle — also to climate researchers and oceanographers.

Plans for the deployment of advanced purpose-built sensors have been frustrated for the past few years. But eleven such sensors are scheduled for launch before the year 2000, several of them by the end of 1996. They will carry with them hopes that the ensuing data will ultimately provide estimates of the rates of other key processes within the global carbon cycle, such as new production and air–sea exchange of carbon dioxide.

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