ATM in checkpoints or cell cycle control, possibly via its action in a p53-dependent process. As in DNA-PK$_{cs}$ mutants, V(D)J recombination is affected, likely accounting for the immune deficiencies in AT patients (*15*). However, other defects in AT patients (for example, cerebellar degeneration) cannot be explained by analogy to MEC1 and DNA-PK$_{cs}$.

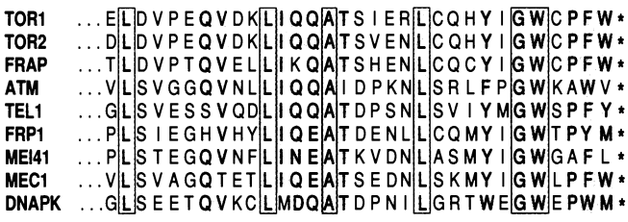

Fig. 2. The unique carboxyl-terminal region. The PIK-related kinases are distinguished by the presence of a conserved, carboxyl-terminal domain. Blue, identical amino acids; green, conservative changes.

The *S. cerevisiae* gene *TEL1* encodes a 322-kilodalton protein that is the closest homolog to human ATM (*16*). Originally identified in a screen for strains with abnormal telomere lengths, the *TEL1* mutant has other deficiencies that might be expected given its membership in this family (*17*). In addition to shortening of telomeres, mitotic recombination is increased (albeit to a lesser extent than in cells lacking MEC1 or ATM), and entire chromosomes are lost at a higher rate. Curiously, AT cell lines also show shortened telomeres and decreased chromosome stability (*18*). *TEL1* apparently is also functionally related to *MEC1*, because increased expression of *TEL1* complements the essential and checkpoint functions of *MEC1* (*19*).

The first mammalian member of this family to be cloned was the 289-kilodalton protein FRAP (FKBP rapamycin–associated protein), a direct target for the FKBP-rapamycin complex in humans and an apparent homolog of the *S. cerevisiae* TOR proteins (*20*). Growth factor–stimulated progression through the G_1 phase of the cell cycle in many cell types is sensitive to rapamycin. Recently, FRAP's function in this pathway was investigated directly (*21*); FRAP is required for p70 S6 kinase activation (resulting in increased translation of certain messenger RNAs), and conservative mutations in the kinase domain abolish this activation. When these mutations were made in the kinase domain of TEL1, telomere shortening was observed, again indicating a loss of function (*16*). Although FRAP can catalyze phosphotransfer to serine in an autophosphorylation reaction, no FRAP-specific PI phosphorylation has been measured so far. Likewise, only serine and threonine phosphorylation have been observed with DNA-PK$_{cs}$ (*7*).

Another apparent role for this family in cell-cycle control may be the modulation of amounts of cyclin-dependent kinase inhibitors (CDIs). FRAP is presumed to mediate interleukin-2–induced elimination of $p27^{Kip1}$ and increases in $p21^{Waf1/Cip1}$ (rapamycin-sensitive events) (*22*), and $p21^{Waf1/Cip1}$ induction in response to ionizing radiation is impaired in ATM-deficient cells (*13*). No doubt the future will reveal further functional similarities among members of the PIK-related kinase family, possibly including roles for the FRAP/TOR proteins in DNA repair, recombination, and in cell cycle checkpoints.

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Exciting Resonances

In an insulator or semiconductor, absorption of external energy produces an excited electron and a corresponding positively charged hole. Instead of recombining, the electron hole pair can be bound together by Coulombic attraction into a stable hydrogen-like complex known as an exciton. Excitons have the unusual property of being able to transport energy while remaining charge neutral. Energy transport by excitons has been used to explain energy transfer in organic crystals, polymers, liquids, and biological systems such as the photosynthetic reaction center. A method for producing excitons in quantum wells has been reported in the 7 August issue of *Physical Review Letters* by Cao *et al.* of Stanford University (*1*).

Quantum wells, layered structures made from materials with carefully chosen band gaps, offer an ideal way to confine excitons for study. Excitons have already been shown to tunnel through quantum wells as single entities (*2*), but Cao *et al.* have devised a way to create excitons directly in the quantum well region. Their approach involves a cleverly engineered structure: with voltage bias off, free holes from a *p*-doped AlGaAs layer diffuse into the quantum well region. Under an applied voltage, the free electrons in an *n*-doped GaAs layer can tunnel into the quantum well and combine with the trapped holes to form excitons. Because the electron energy can be adjusted so that the tunneling is resonant (that is, the energy of the hole and the tunneling electron become matched to that of the exciton they will create), the combination rate can be enhanced.

Now that excitons can be directly created inside quantum wells, some interesting fundamental phenomena in quantum electrodynamics may come under experimental scrutiny (*3*). For instance, just as the effect of vacuum fluctuations on single atoms can be studied in microcavities, it may be possible to examine how the fluctuations affect exciton resonance. On the practical side, because excitons can emit radiation when they go to the crystal ground state, the method of Cao *et al.* may also lead to a new class of optoelectronic devices.

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