understanding of the molecular events that take place during resist coating, pre-exposure baking, exposure, post-exposure baking, development, and drying.

Lin *et al.* report an important step toward this goal by demonstrating the use of x-ray and neutron reflectometry as a general-purpose tool to directly measure acid diffusion and the deprotection reaction front in chemically amplified resists with nanometer resolution. This technique allows exploration and identification of the fundamental chemical and transport mechanisms that are operational in candidate resist materials chemistry systems.

The work of Lin *et al.* opens a window of opportunity to construct structure-property relationships between chemical transport mechanisms and ultimate resist resolution. It may also lead to insights into the ultimate, intrinsic resolution limits and critical dimension control of polymer-based imaging materials.

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PERSPECTIVES: SEA LEVEL CHANGES

How Alaska Affects the World

Mark F. Meier and Mark B. Dyurgerov

As global sea levels rise, scientists are struggling to quantify the contributions made by glaciers around the world. On page 382 of this issue, Arendt *et al.* (*1*) report an important piece of the puzzle. They show that the Alaskan glaciers produce more meltwater than previously allowed for in models. Future sea level changes may therefore be underestimated.

The societal and economic impacts of rising sea levels are already evident (*2*). Beach erosion and shoreline retreat impact valuable real estate and the livelihood of many waterfront communities. Sea level changes affect the rate of saltwater incursion into coastal aquifers, the extension of the saltwater wedge in estuaries, and the probability of damage from storm surges along coastlines. More than 100 million people live within 1 meter of the mean sea level, and the problem is especially serious for low-lying small island nations.

Global sea level rise is caused mainly by ocean expansion due to warming (steric rise) and by ocean mass increase due to the melting of glaciers on land (eustatic rise). The laser-altimeter surveys of Alaskan glaciers reported by Arendt *et al.* (*1*) add fuel to a controversy about the relative importance of these contributions (*3*).

Estimates of the global contribution of glaciers (not including the Antarctic and Greenland ice sheets) to sea level rise are traditionally based on labor-intensive mass-balance (snow/ice input minus ice/water output) measurements on the glacier surface (*4*, *5*). Many such measurements have been made on small- to medium-sized glaciers in Europe, but the larger glaciers in other parts of the world are poorly sampled.

Alternatively, numerical models of global glacier wastage may use temperature and precipitation data calibrated by a limited number of mass-balance observations (*6*, *7*). These models suffer from the paucity of precipitation data in some highly glaciered parts of the world. Serious problems exist with both approaches in southern and southeastern Alaska and adjacent Yukon/northwestern British Columbia.

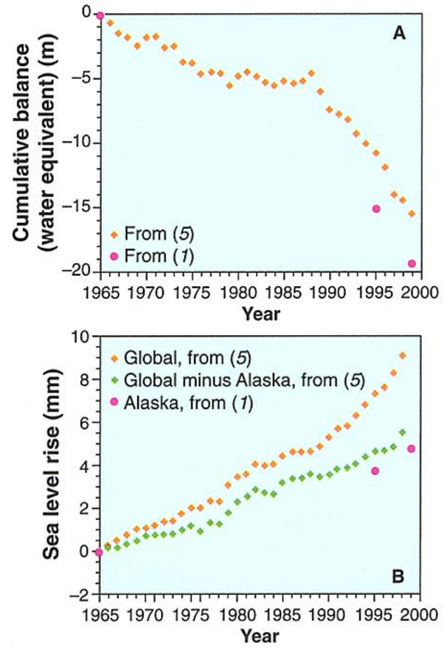
The mountains around the Gulf of Alaska contain up to 90,000 km^2 of glacier area. They include the largest glaciers outside of the polar regions and are characterized by very high rates of precipitation and runoff—as much as 4000 mm/year. However, long-term mass-balance time series are available for only three relatively small glaciers in the region—Gulkana, Wolverine, and Lemon Creek Glaciers—totaling just 53 km^2.

Are these data representative of the many large glaciers? According to the results of Arendt *et al.* (*1*), they are. For the three glaciers mentioned above, laser-altimeter results and mass-balance observations agree within the error limits (*8*) (see panel A in the first figure). The wastage of these glaciers follows a global trend of accelerated melting since 1988 (see the second figure) (*9*).

This consistency allows an assessment of the impact of all Alaskan glaciers on global sea level. The Alaskan glaciers (see panel B in the first figure) (*1*) contribute about one-half that of all glaciers worldwide, although Alaska contains only about 13% of the world's glacier area. This result was suggested earlier on the basis of a rather dubious model (*10*), but recent precipitation/temperature model results (*6*, *7*, *11*) grossly underestimate the Alaskan contribution. Unfortunately, these climatic models are the basis for most published projections of future sea level rise (*3*).

Recent models used for projection allow for the shrinkage of glacier area that accompanies thinning (*3*, *11*). The larger the glacier, the less the relative decrease in area for a given loss of thickness. The huge glaciers of Alaska are now seen to be major contributors to sea level rise; unfortunately, they were not included in published inventory data used in (*3*, *11*). The future rate of decrease in area, and hence in melt volume, will be less than estimated in these recent models. This is another reason why existing projections underestimate future sea level rise.

Recent studies (*12*) indicate that the global pattern of sea level rise measured by satellite altimetry for 1993 to 1998 matches the calculated thermal expansion of ocean waters, leaving little room for a eustatic component. In contrast, Earth rota-



The melting of Alaskan glaciers. (A) Surface mass-balance observations (*5*) and laser-altimeter measurements (*1*), averaged for three Alaskan glaciers (*14*). **(B)** Sea level rise due to glacier wastage, including area-weighted global total based on mass balance (*5*), global total minus Alaskan glaciers (*5*), and Alaskan glacier total from laser-altimetry (*1*). The latter two curves are approximately equal, showing that Alaska provides half of the total contribution of glaciers to sea level rise (*14*).

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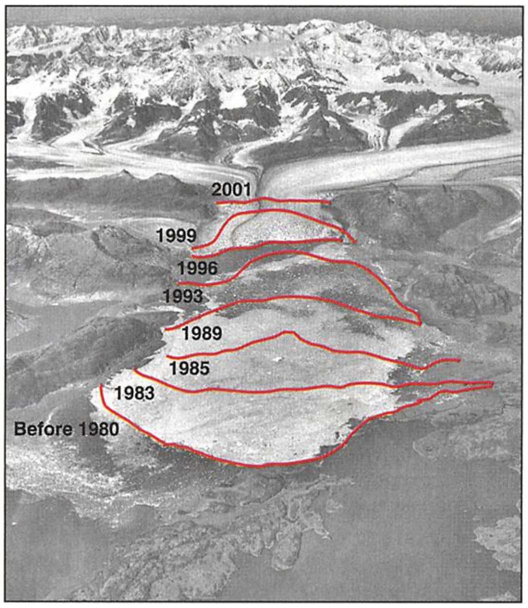

Recent wastage of Columbia Glacier, Alaska. This large glacier is rapidly losing mass by thinning and the discharge of icebergs into the sea. Aerial photograph taken in September 1996.

tion and geodynamic data suggest that a eustatic component is necessary to explain the data (*13*). The new glaciological results of Arendt *et al.* (*1*) provide support for a eustatic contribution. They identify a major eustatic contribution to sea level change near the Gulf of Alaska, probably the largest in the world.

To make confident projections for the course of sea level rise in the 21st century, we must first understand its causes in the past century. The work of Arendt *et al.* shows the way ahead. We need more laser-altimeter studies of glaciers in areas where mass-balance observations are few. We also need better climate-glacier synthesis models and improved parameterization of atmospheric general circulation models for mountain regions, especially maritime areas such as coastal Alaska. Satellite geodesy, oceanography, glaciology, geodynamics, and climate change must all contribute if this important aim is to be achieved.

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14. In (A), laser-altimeter results were arbitrarily cumulated from 1965 to be comparable with the surface balance observations. In (B), the data on Alaska from (*5*) have been multiplied by the ratio 90,000/74,000 because of the larger area considered in (*3*).

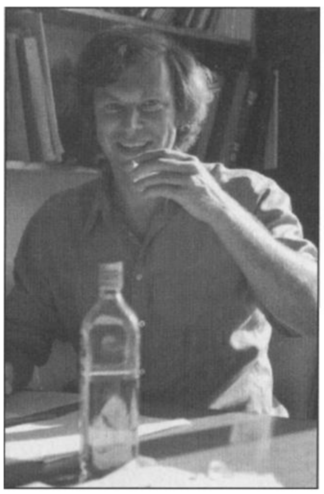
PERSPECTIVES: CELL BIOLOGY

When Wee Meets Whi

Peter Sudbery

Most cell types maintain a constant size over many generations and must reach a critical size before they can divide. This suggests that cells must have a mechanism to coordinate cell division (mitosis) with attainment of the critical size (*1*). Working with the fission yeast *Schizosaccharomyces pombe* in the 1970s, Paul Nurse and his colleagues identified mutants that divided at an abnormally small size and called them "*wee*" mutants after the Scottish word for small. Analysis of these mutants was instrumental in elucidating regulation of the cell cycle in fission yeast by the cyclin-dependent kinase (Cdk) encoded by the *cdc2* gene (*2*). Later, small-size mutants were discovered in the budding yeast, *Saccharomyces cerevisiae*, and were promptly given the moniker *whi*, pronounced "wee" (see the photograph, this page). The *WHI1-1* allele isolated in the budding yeast screen (*3*) helped to identify the G_1 cyclins, which associate with Cdks to promote commitment to cell division in most eukaryotic cells (*4*).

Yeast size mutants are difficult to isolate because there is no obvious difference between the colonies they form and those formed by wild-type cells (for example, in terms of growth rate). In fact, some mutations may even alter cell size without affecting the size control mechanism itself, making it even more difficult to identify those genes involved in size homeostasis. One way to identify genes genuinely involved in the size control mechanism is to assess the effect of mutating each gene in the yeast genome. This is precisely the approach taken by Jorgensen *et al.* (*5*) and presented on page 395 of this issue. Their comprehensive screen of all 6000 gene deletion mutants in *S. cerevisiae* yielded 500 mutants with altered cell size. From their screen, these authors identified a number of genes that seemed to be genuinely involved in size homeostasis, including, unexpectedly, 15 genes that are important for ribosome biogenesis.



A Whi dram. The isolation of the *S. pombe wee* mutants by Paul Nurse and Peter Fantes spurred Bruce Carter and me to screen for small-size mutants in *S. cerevisiae*. I bet Bruce a bottle of the best Irish Whiskey that we would not be able to isolate such mutants. Happily, I lost the bet, and we identified *S. cerevisiae* small-size mutants, which we called *Whi* in honor of the bet. Bruce can be seen here enjoying the spoils of victory, a bottle of Black Bushmills.

Analysis of budding yeast mutants defined a checkpoint in late G_1 phase of the cell cycle called Start (*6*). Once cells pass Start, they are committed to mitosis, but in order to divide, they must have reached a critical size (*7*). The critical size is sensitive to growth rate, so that slow-growing cells pass Start at a smaller size than fast-growing cells. Start is initiated by Cln3p, the protein encoded by the *WHI1-1* gene (subsequently renamed *CLN3*). Cln3p integrates signals about cell size and growth rate. When the critical size is reached, Cln3p associates with a Cdk called Cdc28p, which activates two transcription factors, SBF (Swi4p-Swi6p) and MBF (Mbp1p and Swi4p) (*8*). These transcription factors drive the expression

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