The Ultra centrifuge

By Jeffrey M. Perkel

Step into any molecular and cellular biology laboratory anywhere in the world, and chances are you’ll see an ultracentrifuge sitting somewhere nearby. Figuring prominently in the purification protocols for everything from DNA and protein to Golgi and mitochondria, these machines rely on the same physical principle that makes children giddy on playground carousels: As the rotor (or carousel) spins, objects are pushed away from its axis of rotation via centrifugal force. In a carousel, that force may be a few times that of gravity (G); in an ultracentrifuge spinning at 100,000 revolutions per minute, the force approaches one million G’s.

The prototypical ultracentrifuge was designed in 1924 by Swedish chemist Theodor Svedberg, who built the apparatus for his work on the physical properties of colloids. Svedberg won a Nobel Prize for his work, and in his honor scientists still measure massive particles in Svedberg (S) units (as in the 80S ribosome). Molecular and cellular biologists alike have since embraced his technology. Meselson and Stahl used an ultracentrifuge in 1958 to pin down the semiconservative nature of DNA replication. Forty-six years later, many still swear that the all-around cleanest plasmid DNA comes not from the tip of some newfangled plastic purification column, but from midway down a cesium chloride-ethidium bromide gradient created over a span of eight hours at 55,000 rpm. Likewise, transcription jockeys still purify ribosome-studded mRNAs, and cell biologists still harvest mitochondria by driving those particles through density gradients during prolonged centrifugation. There are other more modern applications, too: It’s become a valuable tool in both proteomics research and vaccine development.

Svedberg’s first ultracentrifuge spun samples at 12,000 rpm, producing a force 7,000 times that of gravity, but today’s machines provide a bit more rotational juice. The Optima L-XP ultracentrifuge diagrammed here, for instance, from Beckman Coulter of Fullerton, Calif., can spin samples at 100,000 rpm, producing a force 7,000 times that of gravity. Control panel and user interface

1. Electrical braking, as opposed to mechanical, is used to avoid disrupting fragile gradients and sample separations.
2. The vacuum system is automatically activated at the start of a run. The rotor will accelerate to 3,000 rpm and hold that speed until a vacuum level less than 5 microns is reached. The diffusion pump is then activated to achieve a vacuum of less than 5 microns. The vacuum permits higher rotational velocity without generating heat from friction with the surrounding air.
3. The L-XP supports fixed-angle, vertical, and swinging-bucket rotors. In a swinging-bucket rotor such as the one shown here, the bucket sways out horizontally during the run to produce a clear path through which the sample passes.
4. The vacuum system is automatically activated at the start of a run. The rotor will accelerate to 3,000 rpm and hold that speed until a vacuum level less than 750 microns is reached. The diffusion pump is then activated to achieve a vacuum of less than 5 microns. The vacuum permits higher rotational velocity without generating heat from friction with the surrounding air.

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