APPLICATIONS

Diagnosing Chromosome Disorders

Although scientists have been able to microscopically observe chromosomes since the mid-1800's, a century passed before staining techniques were developed to examine them on a specific and individual basis. The chromosomes could then be arranged according to size and banding pattern for detailed examination – a display called a karyotype. Once it became possible to accurately identify individual chromosomes, abnormalities in chromosome number (such as trisomy 21, also known as Down syndrome) were discovered. Karyotypes can also identify deletions, duplications, and inversions of chromosomal segments.

Although abnormalities on the order of millions of base pairs can be detected using the basic chromosomal banding techniques, smaller alterations cannot be discerned. More recent technologies, such as fluorescence in situ hybridization (FISH) and array comparative genome hybridization (aCGH), allow a finer level of resolution, with the ability to identify submicroscopic chromosome changes.

Array CHG has replaced karyotyping as the standard chromosome diagnostic tool to detect abnormalities in chromosome number, microdeletions and other chromosome imbalances. It is used in both prenatal and postnatal settings. Depending on the specific array, it can detect chromosomal imbalances as small as 1,000 bp in size. The use of array CGH has significantly increased the diagnosis of chromosomal imbalances among individual with clinical anomalies.

Chromosome studies, their behavior in cell division, the formation of egg and sperm and the concept of karyotyping are regularly discussed in Biology classes (standards 4, 11, 12 and related sub-standards). Karyotyping to diagnose chromosomal disorders is examined in the Career/Tech course Intro to Biotechnology (COS objectives 1 and 5). The techniques of FISH and aCGH should also be discussed with students in these classes, although many of the technical details may be outside the scope of the high school classroom. It is important for students to realize that there are a number of genetic disorders that cannot be identified at the karyotype level, but the newer technologies bridge the gap between studies of stained chromosomes and DNA sequencing.

The HudsonAlpha team has crafted Disorder Detectives®, a kit that allows students to take on the role of a cytogeneticist working in a hospital or clinic. Students are given a case study and set of human chromosome clings and must arrange the chromosomes into a completed karyotype, analyze the karyotype and diagnose their patient. Many types of typical and atypical karyotypes are presented. Students explore technologies such as FISH, aCGH and sequencing to learn how laboratories can diagnose even the smallest genetic structural changes. Geneticists, genetic counselors and laboratory technicians are highlighted as careers that utilize these types of technologies. The activity is available from AMSTI/ASIM and can be purchased from Carolina Biological Supply. More information can be found at www.hudsonalpha.org/available-educational-kits.

ChromoSock® kits, developed at HudsonAlpha, use custom-made socks as models for chromosomes to examine the movement of chromosomes during cell division. Providing a physical manipulative allows students to investigate the impacts of errors in cell division. ChromoSock Meiosis and Modeling Mendel's Laws® are available through AMSTI/ASIM and for purchase through Carolina Biological Supply. More information can be found at www.hudsonalpha.org/available-educational-kits.