Title: Genetics of Individuals and Populations

Abstract: An organism’s physical traits, or phenotype, are a product of its genotype, which is the combination of alleles (gene variants) inherited from its parents. To varying degrees, genes interact with each other and environmental factors to generate traits. The distribution of alleles and traits within a population is influenced by a number of factors, including natural selection, migration, and random genetic drift.

In this video, JoVE introduces some of the foundational discoveries in genetics, from Gregor Mendel’s elucidation of the genetic basis of inheritance, to how natural processes affect allele distributions within populations, to the modern synthesis of biology that brought together Mendelian genetics and Darwinian evolution. We then review the questions asked by geneticists today regarding how genes influence traits, and some of the main tools used to answer these questions. Finally, several applications of techniques such as genetic crosses, screens and evolution experiments will be presented.

Application videos:

1. Forward Genetic Approaches in Chlamydia trachomatis **(50636 Thumbnail @ 8:00 – Microscopy of Chlamydia infected cells)**

Description: Classical genetic techniques such as screens continue to see important uses, especially in organisms not amenable to manipulation by molecular tools like genetic transformation. In this article, researchers carried out a forward screen in the pathogenic bacteria *Chlamydia trachomatis* using chemical mutagenesis. The mutant bacteria were then subjected to whole-genome sequencing to identify all the generated mutations, which were correlated with observed phenotypic changes in the bacteria’s ability to infect cells.

2. A Quantitative Fitness Analysis Workflow **(4018 Thumbnail @ 10:19 Fitness analysis results highlighting suppressors (red) and enhancers (green))**

Description: This video presents both manual and fully automated techniques for performing quantitative fitness analysis in yeast. This technique generates yeast growth curves, which establish the fitness, or relative reproductive success, of a particular yeast strain. By crossing yeast strains with various mutations, or by culturing them in different environmental conditions, researchers can study the role of genetic interactions in a high throughput manner.

3. The Use of Chemostats in Microbial Systems Biology **(50168 Thumbnail @ 9:25 – View of the Chemostat)**

Description: A chemostat is designed for continuously culturing cells while specifically controlling their growth rate. In this video, researchers demonstrate how to establish and maintain a chemostat culture. They also present several applications of chemostat technology, such as comparing growth rate differences between genotypes and studying experimental evolution in response to limiting specific nutrients.

4. Monitoring Intraspecies Competition in a Bacterial Cell Population by Cocultivation of Fluorescently Labeled Strains **(51196 Thumbnail @ 4:52 – Blue and yellow bacterial colonies)**

Description: Due to the high growth rate of many microbial organisms, genetic changes that alter fitness can shift the genetic composition of an entire population in a short period of time. Here, researchers studied targeted mutations by fostering competition in bacterial co-cultures. Individual bacterial strains were uniquely labeled with fluorescent markers, mixed in equal proportion, and grown under experimental conditions. Visualization and enumeration of surviving strains was used to assess the fitness effects of specific mutations.

5. *In Vivo* Modeling of the Morbid Human Genome using *Danio rerio* **(50338 Thumbnail @9:35 – Zebrafish embryo staining results)**

Description: Due to their evolutionary relationship with humans, genetically tractable model organisms can be used to study the function of human genes. Here, the role of clinically relevant human mutations in the development process is studied in zebrafish. Molecules called morpholinos, which “knockdown” the expression of a target gene, and messenger RNAs expressed from either wild-type or mutant versions of a gene are injected into zebrafish embryos, either alone or in various combinations. The resulting phenotypes allow scientists to assess the functional relationship between different alleles of the gene of interest, for example, whether the mutation is hypomorphic (where the mutant gene product has reduced function) or dominant negative (in which case the mutated product “poisons” the activity of unmutated ones).

Related Videos

5026 – Understanding Concentration and Measuring Volumes

5095 – Yeast Maintenance

5325 – An Introduction to Developmental Genetics

5541 – Genetic Crosses