Genomics and the use of Next Generation Sequencing (NGS) Techniques
Genomics

The study of the structure, organization, function, evolution of genomes (including interactions with the environment)
Genomics before NGS

Rediscovery of Mendel's laws helps establish the science of genetics

Watson and Crick identify DNA (the double helix) as the Chemical basis of heredity

Sanger and Gilbert derive methods of sequencing DNA

Human Genome Projects (HPG) begins-an international effort to map and sequence all the genes in the human genome

Working Draft of the human genome sequencing complete

Human genome project completed 2003
Human genome project
Cost for sequencing genomes rapidly reduced
Human Genomes Sequenced Annually

ABI 3730xl 1998: 0.00
Genome Analyzer 2005: 1.3
Genome Analyzer IIx 2009: 10
HiSeq 2000 2011: 207
HiSeq 2500 2013: 625
HiSeq X Ten 2014: 18,000
Current research: Comparative genomics

Some of the animals whose genomes are being or have been sequenced:

- Platypus *Ornithorhynchus anatinus*
- Dog *Canis familiaris*  Photo: Courtesy of The Broad Institute of MIT and Harvard
- African elephant *Loxodonta africana*
- Fruitfly *Drosophila melanogaster*
- Silkworm *Bombyx mori Daza*  Photo: Alden M. Johnson, California Academy of Sciences
- Cow *Bos taurus*  Photo: Courtesy of Terri Hobbs (www.crazyforcows.com)
- European rabbit *Oryctolagus cuniculus*
- Honey Bee *Apis mellifera*  Photo: Courtesy of Scott Bauer, USDA/ARS/Laboratories
- Armadillo *Dasypus novemcinctus*  Photo: Courtesy of B. Bagatto, Department of Biology, University of Akron
- Roundworm *Caenorhabditis elegans*  Photo: Courtesy of Erik Jorgensen, University of Utah
- Zebrafish *Danio rerio*
- Mouse *Mus musculus*  Photo: Courtesy of Jackson Laboratories
- Chicken *Gallus gallus*
- Opossum *Monodelphis domestica*  Photo: Courtesy of Don Sakaguchi
- Cat *Felis domesticus*  Photo: Courtesy of Dr. Kristina Narfstrom, University of Missouri-Columbia

National Human Genome Research Institute
What is NGS?
NGS platforms

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Illumina

ABI SOLiD
Illumina technologies

MiSeq Series

NextSeq Series

HiSeq Series

HiSeq X Series
Making Libraries

Cluster generation

Sequencing

Data Analysis
Paired-End Sequencing
Multiplexing - barcoding

Library Preparation

Pool

Sequence

Demultiplex

Align

Index 1
(CATTCCG)

Index 2
(AACTCTGA)

Sequence Output to Data File

CATTCCGACGGATCG
AACTGAGTCGGATA
AACTGATCGGGATCG
CATTCCGTGCCAGTC
AACTGAACCTGATG
AACTGAGATTACA
CATTCCGAATTCATT
CATTCCGAACTCCGA

Legend:
- **Library 1 Barcode**
- **Library 2 Barcode**
- **Sequencing Reads**
- **DNA Fragments**
- **Reference Genome**
Alignment and Data analysis
Scope of Sequencing
Diversity studies

A reference genome for common bean and genome-wide analysis of dual domestications

Schmutz et. al 2014 Nature Genetics 46
Expression studies

The developmental transcriptome of *Drosophila melanogaster*
Dissecting biological “dark matter” with single-cell genetic analysis of rare and uncultivated TM7 microbes from the human mouth

PNAS, 104 (2007)
Forward genetics - Isolating Mutant genes

A diploid wheat TILLING resource for wheat functional genomics

*BMC Plant Biology* 2012, 12:205
Metagenomics
A metagenomics and case-control study to identify viruses associated with bovine respiratory disease.

Ng TF\textsuperscript{1}, Kondov NO\textsuperscript{1}, Deng X\textsuperscript{1}, Van Eenennaam A\textsuperscript{2}, Neibergs HL\textsuperscript{3}, Delwart E\textsuperscript{4}.

Sequencing ancient genomes

Biological Question?
Exercise

• Think about what you work on and how sequencing could play a role in your science.
• Come up with a biological question that sequencing could help answer in your work
• What information do you want from the data?
• What sequencing approach could you use?
Third Generation sequencing