DNAi DVD CONTENTS

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THEMES

• DNA MOLECULE •

Discovery of DNA
A pre-1953 notion _ biology prior to discovery of the double helix . . .  François Jacob
DNA is the genetic material _ the experiment that identified DNA as the genetic material . . .  Maclyn McCarty
Chargaff's ratios _ the DNA base ratio rules . . .  Erwin Chargaff
Race to discover the structure _ the race between King's College, London, and other groups to define the structure of DNA . . .  Raymond Gosling
Clue: position of phosphates _ realizing phosphates are on the outside of the structure . . .  Raymond Gosling
An earlier DNA model _ Franklin's analysis of Watson and Crick's early model of DNA . . .  Raymond Gosling
Clue: X-ray diffraction _ how the X-ray diffraction camera works . . .  Raymond Gosling
The answer _ working out the structure of DNA . . .  Jim Watson
DNA: the secret of life _ on his and Francis Crick's gigantic breakthrough . . .  Jim Watson
DNA: the key to understanding _ why the discovery of DNA's structure was so important . . .  Francis Crick

Structure of DNA
An elegant structure _ the elegant simplicity of Watson and Crick's model . . .  Raymond Gosling
Replication models _ the different models proposed for DNA replication . . .  Matthew Meselson
The correct model _ Meselson and Franklin Stahl's experiment to determine the correct DNA replication mode . . .  Matthew Meselson
Replicating the helix _ animation
Mechanism of replication _ animation
How DNA is packaged _ animation

Organization of DNA
Billions of bases _ there are 2.9 billion letters in the human genome . . .  Mark Adams
Chromosome map _ animation
100 km of DNA _ the length of the human genome . . .  John Sulston
Walking down a chromosome _ traveling down the genome . . .  Ewan Birney
Coding vs. non-coding _ how much of the genome is active? . . .  Jim Kent
How much DNA codes for protein? _ animation
An important gene cluster _ a cluster of immunity genes on chromosome six . . .  Jim Kent
Bacterial vs. human genome _ human genes are organized in patches of information . . .  Eric Lander
• DNA IN ACTION•

**The genetic code**
The digital code
The coding problem
DNA has four units
Defining the gene
3 DNA bases = 1 amino acid
Code analogies
Triplet code
Cracking the first codon
Cracking the code
Universal code

*DNA is a digital code that can be read . . . Leroy Hood
the problem posed by Watson and Crick's model . . . Sydney Brenner
animation
matching the gene to protein sequence . . . Sydney Brenner
the mathematician George Gamow's idea that three DNA bases encode one amino acid . . . Marshall Nirenberg
the idea of applying a code to DNA sequence . . . Sydney Brenner
deciphering the first amino acid codon . . . Marshall Nirenberg
deciphering every triplet code . . . Marshall Nirenberg
all forms of life use the same genetic instructions . . . Marshall Nirenberg*

**The Central Dogma & gene expression**
The Central Dogma & gene expression
Protein synthesis
The role of the ribosome
Transcription
Explaining the Central Dogma
RNA splicing
Processing mRNA
Translation
Gene regulation
The lac operon model

*DNA makes RNA makes protein . . . Jim Watson
synthetic RNA stimulates protein synthesis . . . Marshall Nirenberg
ribosomes recognize a triplet code . . . Marshall Nirenberg
animation
the mechanism of protein synthesis and the virus (phage) experiment that proved it . . . Sydney Brenner
RNA is spliced . . . Tom Cech
mRNA editing by the spliceosome . . . Eric Lander
animation
the regulation of genes by control proteins . . . Walter Gilbert
his model for bacterial gene regulation . . . François Jacob*

**Mutation & evolution**
Random mutations
Sickle cell
DNA damage
Junk DNA & evolution
Humans & chimps
Regulatory networks
Differences & similarities
Evolutionary relationships
Smell receptors
What came first: DNA or RNA?

*random mutations are necessary for evolution . . . Jim Kent
animation
junk DNA may have important evolutionary functions . . . Eric Lander
humans and chimps share around 99% of their DNA . . . Mary-Claire King
the importance of regulatory systems for evolution . . . Leroy Hood
dNA variations result in differences between individuals . . . Robert Plomin
the conservation of life processes . . . John Sulston
every gene has a distinctive evolutionary history . . . Eric Lander
evidence that RNA evolved before DNA . . . Tom Cech*

• GENETICS TO GENOMICS•

**Key experiments & techniques**
Polymerase chain reaction
DNA variation
DNA fingerprinting
First recombinant DNA
Mechanism of recombination
Microarray analysis
DNA transfer: agrobacterium
DNA transfer: gene gun

*discovery of the PCR technique . . . Kary Mullis
measuring DNA variation: techniques and applications . . . Mark Skolnick
using minisatellites (tandem DNA repeats) to create unique genetic profiles . . . Alec Jeffreys
describing the first experiment with recombinant DNA . . . Paul Berg
studying gene expression using microarrays . . . Pat Brown
transferring genes into plant cells using agrobacterium . . . Robert Horsch
inserting genes into plant cells using a gene gun . . . Robert Horsch*
**Key experiments & techniques**

Sequencing DNA
- inside a DNA sequencing machine . . . Leroy Hood
- the speed of sequencing since automation . . . Mike Hunkapiller

Sequencing genomes

**Advances & applications**

Cross-species recombination
- first experiment to recombine DNA from different species . . . Stanley Cohen

Birth of genetic engineering
- significance of his experiment with Stanley Cohen to clone toad DNA . . . Herbert Boyer

The impact of cloning
- the implications of cloning mammalian genes . . . Herbert Boyer

Cloning DNA in bacteria
- importance of being able to clone DNA using bacteria . . . Paul Berg

Risks of DNA recombination
- potential risks associated with recombining DNA . . . Robert Pollack

Lab safety
- demonstrating the P4 lab containment suit he developed for working with high risk substances . . . Emmett Barkley

Insulin production
- the Genentech method of producing . . . David V. Goeddel

First transgenic crop
- the first transgenic crop, engineered by Monsanto . . . Robert Horsch

Cotton plants
- cotton plants engineered to be pest resistant . . . Jim Watson

GM crop concerns
- raising concerns associated with GM crop production . . . Jim Kent

**The Human Genome Project**

The aim
- the aim of the Human Genome Project . . . Jim Watson

The motivation
- the justification for the Human Genome Project . . . Francis Collins

Public & private
- comparing methods used by the public and private teams . . . Gene Myers

Public project sequencing
- animation

Assembling the fragments
- problems assembling the genome fragments . . . Jim Kent

Private project sequencing
- animation

Reading the genome
- interpreting the completed human genome sequence . . . Ewan Birney

The completed genome
- the completion of the draft human genome sequence . . . William J. Clinton

Outcome of the HGP
- a new paradigm for studying biology . . . Eric Lander

After the HGP
- a new foundation for science . . . J. Craig Venter

**Bioinformatics**

An overview
- using computers to assemble genomes and interpret data . . . Gene Myers

Solving a problem
- developing the tools to sequence the genome . . . J. Craig Venter

Computing power
- computational power of a processing farm . . . Ewan Birney

Analyzing your genes
- understanding the genome will lead to medical advances . . . Leroy Hood

Proteomics
- studying proteins to understand disease . . . Scott Patterson

Implications for the future
- new tools for redesigning life . . . Leroy Hood

**HUMAN GENETICS**

**Disease research**

The challenge of gene hunting
- the challenge of finding a disease gene . . . Francis Collins

Locating disease genes
- locating disease genes using markers . . . David Botstein

Impact of the genome projects
- the increased speed of gene searching . . . Ewan Birney

Animal models
- using mouse models to study disease . . . Mario Capecchi

The DMD approach
- gene replacement therapy in Duchenne muscular dystrophy (DMD) . . . Kay Davies

Gene expression patterns
- gene expression patterns in diseased cells . . . Pat Brown

Gene switches
- switching genes on and off to study disease . . . Mario Capecchi

Gene manipulation
- using embryonic stem cells to make mouse models . . . Mario Capecchi
Disease research
Living with sickle cell
Inheriting sickle cell

Work on cancer
Mutations & cancer
Tumor growth
Cancer genes
Early cancer studies
Finding cancer genes
Using family trees
Identifying BRCA1
Looking for BRCA2
Limitations of testing
Hopes for the future

Screening & treatment
Leukemia: the Gleevec story
How Gleevec works
Gleevec: first trials
Developing other cancer drugs
More questions than answers
Genetic screening
Offering options
Testing for a reason

Behavioral genetics
Genetic pre-wiring
Nature vs. nurture
Complex behavior
Twin studies
Prediction & prevention
Heritability of behaviors
Mental illness & creativity
Basis of complex disorders

Human origins
Neandertal DNA
Neandertal & human ancestry
Counting DNA mutations
Tracking human history
The evolutionary puzzle
The divergence of Neandertals
A recent common ancestor
Classification and value

(Continued)
_ how sickle cell has affected her life . . . Katreece McGhee
_ how she inherited sickle cell . . . Katreece McGhee

_ cancer is caused by an accumulation of mutations . . . Bruce Ames
_ animation
_ describing tumor suppressors and oncogenes . . . Mike Wigler
_ studying cancer prior to understanding its mechanisms . . . Mary-Claire King
_ searching for candidate genes in families with breast cancer
_ . . . Mary-Claire King
_ identifying and tracking genetic markers using family trees . . . Barbara Weber
_ finding and cloning the first breast cancer gene: BRCA1 . . . Mark Skolnick
_ finding the second breast cancer gene: BRCA2 . . . Mark Skolnick
_ current status of testing for cancer genes . . . Mary-Claire King
_ hopes for cancer treatments . . . Mary-Claire King
_ the development of Gleevec, a drug to treat leukemia . . . Brian J. Druker
_ animation
_ the first patient in the Gleevec trials . . . Bud and Yvonne Romine
_ applying the Gleevec model to other cancers . . . Brian J. Druker
_ approaching population screening with caution . . . Francis Collins
_ setting up a screen for muscular dystrophy . . . Kay Davies
_ importance of choice regarding genetic testing . . . Kay Davies
_ schizophrenia: a case for testing . . . Kay Jamison

_ behavior can be both genetically pre-wired and learnt . . . Hubert Markl
_ how much of our behavior can be attributed to genes? . . . Robert Plomin
_ the honeybee as a model for complex behavior . . . Hubert Markl
_ the genetic basis of cognitive traits . . . Robert Plomin
_ predicting and preventing behavioral problems . . . Robert Plomin
_ all behavioral traits have a heritable component . . . Robert Plomin
_ genetic links between mental illness and creativity . . . Kay Jamison
_ understanding the genetic basis of complex traits . . . Robert Plomin

_ comparing Neandertal and modern human mitochondrial DNA
_ . . . Svante Pääbo
_ human origins and our common ancestry with Neandertals . . . Svante Pääbo
_ why the number of mutations in mitochondrial DNA is an underestimate
_ . . . Mark Stoneking
_ using the Y chromosome and other genomic regions to track human history
_ . . . Michael F. Hammer
_ genetic data must be part of a framework . . . Michael F. Hammer
_ fossil evidence shows that Neandertals diverged from modern humans
_ . . . Chris Stringer
_ mitochondrial DNA confirms a recent common ancestor for modern humans
_ . . . Douglas Wallace
_ confounding genetic classification with human worth . . . Hubert Markl
• ETHICS & IMPLICATIONS •

**Eugenics**
Sterilization as a welfare reform... Paul Lombardo
Pre-WWII German eugenics... Jim Watson
American perspective... an overview of eugenics in the USA... Jim Watson
The Buck vs. Bell case... sterilization in the USA: Buck vs. Bell... Paul Lombardo
Reactions to imperfections... should we correct natural genetic imperfections?... Jim Watson
Who should decide?... making life choices and economic considerations... Benno Müller-Hill
Directing our evolution... our responsibility to direct our own evolution... Jim Watson
Classification and value... confounding genetic classification with human worth... Hubert Markl

**Diversity & enhancement**
None of us are perfect... human imperfections and genetic enhancement... Jim Watson
Vanilla children... for diversity and against narrowing the options... Kay Jamison
Designer babies... intervening in a child's future at a genetic or social level... Robert Plomin
Weeding out disease... predictions for gene testing... Bruce Ames
Harrington family... his relationship with his son who has Down syndrome... Roby Harrington
A case for testing... testing and managing genetic disorders... Kay Davies
Protecting diversity... manic depressives: an endangered but valued species... Kay Jamison
A better understanding... improving our species with better education... Hubert Markl

**Ownership & access**
Patenting living organisms... creating and owning living organisms... Ananda Chakrabarty
Selecting genes to patent... a private company's approach to patenting genes... Mark Adams
Patenting chaos... on knowing the function of a gene before you patent... Mary-Claire King
Commercial patents... on patenting genes for commercial purposes... Mary-Claire King
Human genome patents... the human genome sequence is not a basis for a patent... John Sulston
A free flow of information... making sequence public to pre-empt the patents... John Sulston

• REFLECTING ON SCIENCE •

**A selection of views**
Science & faith... reconciling working in science with faith in God... Francis Collins
Playing God... miracles from knowledge, not prayer... Jim Watson
Explaining life through science... reading a letter from Rosalind to her father... Rosalind Franklin's sister
Reading our own code... reflecting on our evolution... John Sulston
Influencing our evolution... eliminating faults in our genetic programming... Raymond Gosling
Manic depression... mental illness and complicated choices... Kay Jamison
Definitions of life... defining what it is to be alive... Tom Cech
Can genetics provide answers?... genetics may not provide the answers we seek... Benno Müller-Hill

**Still to be explored**
Unused tools... gene technology and its possible uses... Robert Pollack
Future of medicine... predictive and preventative personalized medicine... Leroy Hood
Manipulating living systems... manufacturing new proteins in living systems... Robert Horsch
Germline therapy... on needing to make germline therapy reversible... Mario Capecchi
Redesigning organisms... technological advances may allow us to redesign life... Leroy Hood
The future of humans... what will humans look like in 5,000 years?... Ananda Chakrabarty
DNA molecule
- DNA has four units
- Chargaff's ratios
- Triple helix
- Base pairing
- How DNA is packaged *
- DNA unzip
- Chromosome map
- How much DNA codes for protein?

Replication
- Replicating the helix
- Mechanism of replication *

Transcription & translation
- Triplet code
- Transcription *
- mRNA splicing
- Translation *

Experiments & techniques
- Mechanism of recombination
- Microarray
- Polymerase chain reaction
- Sanger sequencing
- Public project sequencing
- Private project sequencing

Disease & mutation
- DNA damage
- Sickle cell
- Tumor growth
- How Gleevec works

(* ) narration options: none, basic, and advanced.

INTERVIEWS

1)

Mark Adams
- Billions of bases
- Selecting genes to patent

Bruce Ames
- Mutations & cancer
- Weeding out disease

Emmett Barkley
- Lab safety

Paul Berg
- First recombinant DNA
- Cloning DNA in bacteria
- Cohesive ends & recombination

Ewan Birney
- Walking down a chromosome
- Reading the genome
- Computing power
- Impact of the genome projects

David Botstein
- Locating disease genes
- Cost of the Human Genome Project
- Opposition to the Human Genome Project

Herbert Boyer
- Birth of genetic engineering
- The impact of cloning
- Why study plasmids?

Sydney Brenner **
- The coding problem
- Defining the gene
- Code analogies
- Explaining the Central Dogma
- The coiled nature of DNA
- Cell organization

Pat Brown
- Microarray analysis
- Gene expression patterns

Mario Capecchi
- Animal models
- Gene switches
- Gene manipulation
- Germline therapy
2)

**Tom Cech**
RNA splicing
What came first: DNA or RNA?
Definitions of life

Ananda Chakrabarty
Patenting living organisms
The future of humans

**Erwin Chargaff**
Chargaff’s ratios

William J. Clinton
The completed genome

**Stanley Cohen**
Cross-species recombination

Francis Collins
The motivation (HGP)
The challenge of gene hunting
More questions than answers
Science & faith

**Francis Crick**
DNA: the key to understanding
The fascination of science
DNA's deceptive "simplicity"
Understanding the brain

**Kay Davies**
The DMD approach
Genetic screening
Offering options
A case for testing

**Brian J. Druker**
Leukemia: the Gleevec story
Developing other cancer drugs

**Rosalind Franklin's sister**
Explaining life through science

3)

**Walter Gilbert**
Gene regulation
Experiments to find RNA
The repressor/inducer system

**David V. Goeddel**
Insulin production

Raymond Gosling
Race to discover the structure
Clue: position of phosphates
An earlier DNA mode
Clue: X-ray diffraction
An elegant structure
Influencing our evolution

**Michael F. Hammer**
Tracking human history
The evolutionary puzzle

**Roby Harrington**
Harrington family

**Leroy Hood**
The digital code
Regulatory networks
Sequencing DNA
Analyzing your genes
Implications for the future
Future of medicine
Redesigning organisms

**Robert Horsch**
DNA transfer: agrobacterium
DNA transfer: gene gun
First transgenic crop
Manipulating living systems

**Mike Hunkapiller**
Sequencing genomes

**François Jacob**
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**Kay Jamison**
Testing for a reason
Mental illness & creativity
Vanilla children
Protecting diversity
Manic depression

4)

**Alec Jeffreys**
DNA fingerprinting

Jim Kent
Coding vs. non-coding
An important gene cluster
Random mutations
GM crop concerns
Assembling the fragments
Mary-Claire King
Humans & chimps
Early cancer studies
Finding cancer genes
Limitations of testing
Hopes for the future
Patenting chaos
Commercial patents

Arthur Kornberg **
Enzymes: DNA polymerase
Studying DNA replication
DNA synthesis

Eric Lander
Bacterial vs. human genome
Processing mRNA
Junk DNA & evolution
Smell receptors
Outcome of the HGP

Paul Lombardo
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Katreece McGhee
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Matthew Meselson
Replication models
The correct model

Benno Müller-Hill
Who should decide?
Can genetics provide answers?

Kary Mullis **
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Need for an RNA template
Pre-WWII German eugenics
Reactions to imperfections
Directing our evolution
None of us are perfect
American perspective
Playing God

Barbara Weber
Using family trees

Mike Wigler
Cancer genes

Maurice Wilkins **
Clue: X-ray diffraction

(**) Nobel Laureate

BACKGROUND BRIEFING

Animator: Drew Berry

Making 3D animations
Working with scientists
Using 3D models
Absolute accuracy
A complex animation

Teacher: Caren Gough

Teacher involvement
Using the DVD
Planning lessons
Interviews on the DVD
Ease of use

_ the process of making 3D scientific animations
_ science as a creative career
_ online libraries of molecules can model interactions
_ ensuring the scientific accuracy of the models
_ creating the replication animation
_ teacher contribution to content selection
_ planning lessons using the DVD content
_ planning lessons using the animationsc
_ scientist interviews provide a unique resource
_ on expertise required to use the DVD