

## DNAi DVD and the DNAi Teacher Guide

The *DNA Interactive (DNAi)* DVD carries approximately four hours of video interviews with 11 Nobel Laureates and more than 50 other scientists, clinicians, and patients. It also holds the complete set of 3-dimensional animations produced for the DNA TV series and DNAi project.

The following pages list video clips and animations from the DVD that would be appropriate to show with specific activities in the *DNAi Teacher Guide*. The clips and animations are listed under “themes” and “additional animations.” The “themes” listing includes relevant interviews and animations that can be accessed from the “themes” section of the DVD. The “additional animations” are best accessed from “animations” button in the DVD main menu.

You can access the *DNAi Teacher Guide* by registering at [www.dnai.org/teacher](http://www.dnai.org/teacher).

### Activity 1: DNAi Timeline: a scavenger hunt

#### 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
The answer	_ the X-ray diffraction picture that revealed the helix . . . Maurice Wilkins
DNA: the key to understanding	_ why the discovery of DNA's structure was so important . . . Francis Crick

##### Structure of DNA

The correct model	_ Meselson and Franklin Stahl's experiment to determine the correct DNA replication mode . . . Matthew Meselson
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##### • DNA IN ACTION •

##### The genetic code

Defining the gene	_ matching the gene to protein sequence . . . Sydney Brenner
Cracking the first codon	_ deciphering the first amino acid codon . . . Marshall Nirenberg

##### The Central Dogma and gene expression

Explaining the Central Dogma	_ the mechanism of protein synthesis and the virus (phage) experiment that proved it . . . Sydney Brenner
The lac operon model	_ his model for bacterial gene regulation . . . François Jacob

##### • GENETICS TO GENOMICS •

##### Key experiments and techniques

Polymerase chain reaction	_ discovery of the PCR technique . . . Kary Mullis
DNA fingerprinting	_ using minisatellites (tandem DNA repeats) to create unique genetic profiles . . . Alec Jeffreys
First recombinant DNA	_ describing the first experiment with recombinant DNA . . . Paul Berg
Microarray analysis	_ studying gene expression using microarrays . . . Pat Brown

## Advances and 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 Human Genome Project

The completed genome

\_ the completion of the draft human genome sequence . . . William J. Clinton

## • HUMAN GENETICS •

### Disease research

Gene manipulation

\_ using embryonic stem cells to make mouse models . . . Mario Capecchi

### Work on cancer

Finding cancer genes

\_ searching for candidate genes in families with breast cancer . . . Mary-Claire King

## Activity 2.

# Finding the Structure: pieces of the puzzle

## 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

\_ the X-ray diffraction picture that revealed the helix . . . Maurice Wilkins

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

## ADDITIONAL ANIMATIONS

### DNA molecule

DNA has four units

Chargaff's ratios

Triple helix

Base pairing

## Activity 3. (Clues to) Copying the Code: examining the evidence

### THEMES

#### • DNA MOLECULE •

##### Structure of DNA

An elegant structure  
Replication models  
The correct model

\_ the elegant simplicity of Watson and Crick's model . . . Raymond Gosling  
\_ the different models proposed for DNA replication . . . Matthew Meselson  
\_ Meselson and Franklin Stahl's experiment to determine the correct DNA replication mode . . . Matthew Meselson

Replicating the helix  
Mechanism of replication

\_ animation  
\_ animation

### ADDITIONAL ANIMATIONS

#### DNA molecule

DNA unzip

#### Replication

Replicating the helix  
Mechanism and replication

## Activity 4. Reading the Code

### THEMES

#### • 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

\_ 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 Central Dogma & gene expression

Need for an RNA Template  
Protein synthesis  
The role of the ribosome  
Transcription  
Explaining the Central Dogma

\_ 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

RNA splicing  
Processing mRNA  
Translation

## ADDITIONAL ANIMATIONS

### DNA molecule

How much DNA codes for protein

## Activity 5.

### Controlling the Code: molecules at work

#### THEMES

• DNA IN ACTION •

#### The Central Dogma & gene expression

Gene regulation \_ every gene has a distinctive evolutionary history ... Eric Lander  
 The lac operon model \_ evidence that RNA evolved before DNA ... Tom Cech

## ADDITIONAL ANIMATIONS

### Transcription and translation

Triplet code  
 Transcription  
 Translation

### Transcription and translation

How DNA is packaged

## Activity 6.

### Manipulation: transferring genes

#### THEMES

• GENETICS TO GENOMICS •

#### Key experiments & techniques

Polymerase chain reaction \_ discovery of the PCR technique ... Kary Mullis  
 DNA variation \_ measuring DNA variation: techniques and applications ... Mark Skolnick  
 DNA fingerprinting \_ using minisatellites (tandem DNA repeats) to create unique genetic profiles ... Alec Jeffreys  
 First recombinant DNA \_ describing the first experiment with recombinant DNA ... Paul Berg  
 Mechanism of recombination \_ animation  
 Microarray analysis \_ studying gene expression using microarrays ... Pat Brown  
 DNA transfer: agrobacterium \_ transferring genes into plant cells using agrobacterium ... Robert Horsch  
 DNA transfer: gene gun \_ inserting genes into plant cells using a gene gun ... Robert Horsch  
 Sequencing DNA \_ inside a DNA sequencing machine ... Leroy Hood  
 Sequencing genomes \_ the speed of sequencing since automation ... Mike Hunkapiller

## 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

## ADDITIONAL ANIMATIONS

### Experiments and techniques

- Polymerase chain reaction
- Sanger sequencing

## Activity 7.

### Gel Electrophoresis: sort and see the DNA

#### THEMES

- GENETICS TO GENOMICS •

#### Key experiments & techniques

- DNA fingerprinting
  - \_ using mini satellites (tandem DNA repeats) to create unique genetic profiles . . . Alec Jeffreys

## Activity 8.

### Model Organisms: the genes we share

#### THEMES

- DNA IN ACTION •

#### The genetic code

- Universal code
  - \_ all forms of life use the same genetic instructions . . . Marshall Nirenberg

#### Mutation and evolution

- Random mutations
  - \_ random mutations are necessary for evolution . . . Jim Kent
- Junk DNA & evolution
  - \_ junk DNA may have important evolutionary functions . . . Eric Lander
- Evolutionary relationships
  - \_ the conservation of life processes . . . John Sulston

• GENETICS TO GENOMICS •

**Key Experiments & techniques**

Sequencing genomes \_ the speed of sequencing since automation . . . Mike Hunkapiller

• 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  
 Animal models \_ using mouse models to study disease . . . Mario Capecchi  
 Gene manipulation \_ using embryonic stem cells to make mouse models . . . Mario Capecchi

**Human origins**

The evolutionary puzzle \_ genetic data must be part of a framework . . . Michael F. Hammer

**ADDITIONAL ANIMATIONS**

**Disease and mutation**

DNA damage

**Activity 9.  
Sequencing**

**THEMES**

• GENETICS TO GENOMICS •

**Key experiments and techniques**

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

**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

**ADDITIONAL ANIMATIONS**

**Experiments and techniques**

Mechanism and recombination  
 Sanger sequencing

## Activity 10.

### Genome: a tour and genetic disorder brochure

#### THEMES

##### • DNA MOLECULE •

##### 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

##### • 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
Living with sickle cell	_ how sickle cell has affected her life . . . Katrece McGhee
Inheriting sickle cell	_ how she inherited sickle cell . . . Katrece McGhee

##### Work on cancer

Mutations & cancer	_ cancer is caused by an accumulation of mutations . . . Bruce Ames
Tumor growth	_ animation
Cancer genes	_ describing tumor suppressors and oncogenes . . . Mike Wigler
Early cancer studies	_ studying cancer prior to understanding its mechanisms . . . Mary-Claire King
Finding cancer genes	_ searching for candidate genes in families with breast cancer . . . Mary-Claire King
Using family trees	_ identifying and tracking genetic markers using family trees . . . Barbara Weber
Identifying BRCA1	_ finding and cloning the first breast cancer gene: BRCA1 . . . Mark Skolnick
Looking for BRCA2	_ finding the second breast cancer gene: BRCA2 . . . Mark Skolnick
Limitations of testing	_ current status of testing for cancer genes . . . Mary-Claire King
Hopes for the future	_ hopes for cancer treatments . . . Mary-Claire King

##### Screening & treatment

Leukemia: the Gleevec story	_ the development of Gleevec, a drug to treat leukemia . . . Brian J. Druker
How Gleevec works	_ animation
Gleevec: first trials	_ the first patient in the Gleevec trials . . . Bud and Yvonne Romine
Developing other cancer drugs	_ applying the Gleevec model to other cancers . . . Brian J. Druker
More questions than answers	_ approaching population screening with caution . . . Francis Collins

- Genetic screening
  - Offering options
  - Testing for a reason
- \_ setting up a screen for muscular dystrophy ... Kay Davies
  - \_ importance of choice regarding genetic testing ... Kay Davies
  - \_ schizophrenia: a case for testing ... Kay Jamison

## ADDITIONAL ANIMATIONS

### Disease and mutation

- DNA damage
- Sickle cell
- Tumor growth
- How Gleevec works

### DNA molecule

- How DNA is packaged

### Experiments and techniques

- Microarray
- Polymerase chain reaction
- Sanger sequencing

## Activity 11. Genome Mining

### THEMES

#### • GENETICS TO GENOMICS •

#### The Human Genome Project

- The aim
  - The motivation
  - Public & private
  - Public project sequencing
  - Assembling the fragments
  - Private project sequencing
  - Reading the genome
  - The completed genome
  - Outcome of the HGP
  - After the HGP
- \_ the aim of the Human Genome Project ... Jim Watson
  - \_ the justification for the Human Genome Project ... Francis Collins
  - \_ comparing methods used by the public and private teams ... Gene Myers
  - \_ animation
  - \_ problems assembling the genome fragments ... Jim Kent
  - \_ animation
  - \_ interpreting the completed human genome sequence ... Ewan Birney
  - \_ the completion of the draft human genome sequence ... William J. Clinton
  - \_ a new paradigm for studying biology ... Eric Lander
  - \_ a new foundation for science ... J. Craig Venter

#### Bioinformatics

- An overview
  - Solving a problem
  - Computing power
  - Analyzing your genes
  - Proteomics
  - Implications for the future
- \_ using computers to assemble genomes and interpret data ... Gene Myers
  - \_ developing the tools to sequence the genome ... J. Craig Venter
  - \_ computational power of a processing farm ... Ewan Birney
  - \_ understanding the genome will lead to medical advances ... Leroy Hood
  - \_ studying proteins to understand disease ... Scott Patterson
  - \_ new tools for redesigning life ... Leroy Hood

## ADDITIONAL ANIMATIONS

### Experiments and techniques

- Microarray
- Sanger sequencing

### DNA molecule

- DNA unzip
- How much DNA codes for protein?



## Activity 12. Human origins: the prehistoric race

### THEMES

#### • DNA IN ACTION •

##### Mutation & evolution

- Random mutations \_ random mutations are necessary for evolution ... Jim Kent
- Sickle cell \_ animation
- DNA damage \_ animation
- Junk DNA & evolution \_ junk DNA may have important evolutionary functions ... Eric Lander
- Humans & chimps \_ humans and chimps share around 99% of their DNA ... Mary-Claire King
- Regulatory networks \_ the importance of regulatory systems for evolution ... Leroy Hood
- Differences & similarities \_ DNA variations result in differences between individuals ... Robert Plomin
- Evolutionary relationships \_ the conservation of life processes ... John Sulston
- Smell receptors \_ every gene has a distinctive evolutionary history ... Eric Lander
- What came first: DNA or RNA? \_ evidence that RNA evolved before DNA ... Tom Cech

#### • HUMAN GENETICS •

##### Human origins

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

### ADDITIONAL ANIMATIONS

#### **Transcription and translation**

- Transcription
- mRNA splicing
- Translation

#### **Disease and mutation**

- DNA damage

## Activity 13. Recovering the Romanovs

### THEMES

#### • MUTATION & EVOLUTION •

- |                            |                                                                                |
|----------------------------|--------------------------------------------------------------------------------|
| Random mutations           | _ random mutations are necessary for evolution . . . Jim Kent                  |
| DNA damage                 | _ animation                                                                    |
| Differences & similarities | _ DNA variations result in differences between individuals . . . Robert Plomin |

#### • HUMAN ORIGINS •

- |                         |                                                                                                   |
|-------------------------|---------------------------------------------------------------------------------------------------|
| Counting DNA mutations  | _ why the number of mutations in mitochondrial DNA is an underestimate . . . Mark Stoneking       |
| Tracking human history  | _ using the Y chromosome and other genomic regions to track human history . . . Michael F. Hammer |
| The evolutionary puzzle | _ genetic data must be part of a framework . . . Michael F. Hammer                                |

### ADDITIONAL ANIMATIONS

#### Experiments and techniques

- PCR
- Sanger sequencing

## Activity 14. Dealing with DNA controversy: issues, arguments, and ethics

### THEMES

#### • ETHICS & IMPLICATIONS •

##### Eugenics

- |                                   |                                                                           |
|-----------------------------------|---------------------------------------------------------------------------|
| Sterilization as a welfare reform | _ sterilization in the USA: used as a welfare reform . . . Paul Lombardo  |
| Pre-WWII German eugenics          | _ eugenics in Nazi Germany . . . 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  
Protecting diversity  
A better understanding

\_ testing and managing genetic disorders ... Kay Davies  
\_ manic depressives: an endangered but valued species ... Kay Jamison  
\_ improving our species with better education ... Hubert Markl

**Ownership & access**

Patenting living organisms  
Selecting genes to patent  
Patenting chaos  
Commercial patents  
Human genome patents  
A free flow of information

\_ creating and owning living organisms ... Ananda Chakrabarty  
\_ a private company's approach to patenting genes ... Mark Adams  
\_ on knowing the function of a gene before you patent ... Mary-Claire King  
\_ on patenting genes for commercial purposes ... Mary-Claire King  
\_ the human genome sequence is not a basis for a patent ... John Sulston  
\_ making sequence public to pre-empt the patents ... John Sulston

**A selection of views**

Science & faith  
Playing God  
Explaining life through science  
Reading our own code  
Influencing our evolution  
Manic depression  
Definitions of life  
Can genetics provide answers?

\_ reconciling working in science with faith in God ... Francis Collins  
\_ miracles from knowledge, not prayer ... Jim Watson  
\_ reading a letter from Rosalind to her father ... Rosalind Franklin's sister  
\_ reflecting on our evolution ... John Sulston  
\_ eliminating faults in our genetic programming ... Raymond Gosling  
\_ mental illness and complicated choices ... Kay Jamison  
\_ defining what it is to be alive ... Tom Cech  
\_ genetics may not provide the answers we seek ... Benno Müller-Hill

**Still to be explored**

Unused tools  
Future of medicine  
Manipulating living systems  
Germline therapy  
Redesigning organisms  
The future of humans

\_ gene technology and its possible uses ... Robert Pollack  
\_ predictive and preventative personalized medicine ... Leroy Hood  
\_ manufacturing new proteins in living systems ... Robert Horsch  
\_ on needing to make germline therapy reversible ... Mario Capecchi  
\_ technological advances may allow us to redesign life ... Leroy Hood  
\_ what will humans look like in 5,000 years? ... Ananda Chakrabarty