*FUNDING FOR THIS PROGRAM*
*IS PROVIDED BY ANNENBERG/CPB*

*TO ADVANCE EXCELLENT TEACHING.*

Narrator: EVERYWHERE WE LOOK,
THERE IS EVIDENCE OF LIFE.

ALL LIFE FORMS CAN BE SEEN TO FOLLOW A PREDICTABLE JOURNEY...

FROM THEIR LIVING BEGINNING

TO A COMMON END IN DEATH.

WITHIN THIS JOURNEY,

LIFE REPRODUCES ITSELF.

POPULATIONS FLOURISH.

MAMMALS GIVE BIRTH
TO THEIR YOUNG.

BIRDS LAY EGGS.

FISH SPAWN.

THE ASTONISHING PROCESS OF LIFE CONTINUES SPONTANEOUSLY

AS EACH GENERATION
LEADS TO THE NEXT.

THE CYCLE CONTINUES, BUT...

WE WILL CREATE
A SPIRAL LIFE CYCLE,

WHERE ONE CHILD'S LIFE CYCLE WILL CONNECT

TO THE NEXT CHILD'S LIFE CYCLE.

THE WORM
TURNED INTO THE DEAD THING,

BUT THEN THE DEAD THING
TURNED INTO THE BEETLE.

THAT WAS VERY SURPRISING.

EVERY ORGANISM HAS DNA,
AND THAT DNA IS VERY SIMILAR

WHETHER YOU'RE A PLANT
OR A BACTERIA OR AN ANIMAL.

THERE ARE DIFFERENT ORGANISMS,
BUT THEY ALL HAVE LIFE CYCLES.

Woman: IT'S INTRIGUING
TO COMPARE PHOTOCOPYING

TO REPRODUCTION
IN THE LIVING WORLD.

IN A PHOTOCOPY MACHINE,

YOU FEED IN THE ORIGINAL,
AND OUT OF THE MACHINE

COMES A COPY.

BUT REPRODUCING LIFE

IS MUCH MORE THAN JUST
PUTTING IN AN ORIGINAL

AND GETTING OUT A COPY.

IT'S AS IF

THE PHOTOCOPY MACHINE ITSELF

COULD GENERATE
REPLICA PHOTOCOPIERS.

WE HAVE NO MACHINES THAT
CAN REPRODUCE THEMSELVES,

WHILE THE LIFE AROUND US
DOES THIS ALL THE TIME.

SO HOW DOES LIFE
ACCOMPLISH THIS?

Grisham: IN OUR FIRST
SESSION TOGETHER, WE NOTED

THAT A LIFE SPAN IS ONE
OF THE ESSENTIAL CHARACTERISTICS

OF A LIVING ORGANISM.

WE OBSERVE CONTINUITY
WITHIN A LIFE SPAN

AS LIFE UNFOLDS.

YOUNG GROW AND DEVELOP
IN PREDICTABLE WAYS INTO ADULTS.

THERE IS ALSO PREDICTABLE CONTINUITY BETWEEN GENERATIONS

AS A RESULT OF LIFE CYCLES.

FROM REPRODUCTION
IN ONE GENERATION

TO REPRODUCTION IN THE NEXT,

OFFSPRING RESEMBLE
THEIR PARENTS.

IN OUR NEXT
TWO SESSIONS TOGETHER,

WE'LL LOOK
AT HOW LIFE CYCLES WORK.

IN TODAY'S SESSION, WE WILL FOCUS ON ANIMAL LIFE CYCLES,

A TOPIC THAT IS FAMILIAR
TO CHILDREN IN ELEMENTARY SCHOOL

WITH THEIR EXPERIENCE
IN OBSERVING THE BIRTH

OF PUPPIES AND KITTENS,

BABY CHICKS,

AND PERHAPS EVEN BEETLES.

PLEASE REMEMBER
THAT THIS IS A CONTENT SERIES,

INTENDED TO HELP FURTHER
YOUR UNDERSTANDING

OF LIFE SCIENCE TOPICS.

SO NOT ALL THE MATERIAL
WE ADDRESS MAY BE APPROPRIATE

TO INTRODUCE AS IS
INTO YOUR CLASSROOM.

WE SEE EVIDENCE OF LIFE
CYCLES ALL AROUND US.

LIFE CYCLES ARE SUCH
A PART OF OUR WORLD

THAT WE AS ADULTS
TAKE THEM FOR GRANTED.

CHILDREN, HOWEVER,
ARE JUST BEGINNING TO GRASP

THE SIGNIFICANCE
OF THE NEVER-ENDING BEGINNINGS

GUARANTEED BY LIFE CYCLES.

WE TALKED WITH DR. RODGER BYBEE,
EXECUTIVE DIRECTOR

OF THE BIOLOGICAL SCIENCES CURRICULUM STUDY,

ALSO KNOWN AS BSCS.

HE IS ONE OF THE ORIGINAL CURRICULUM DEVELOPERS AT BSCS,

AND HAS STUDIED HOW CHILDREN THINK ABOUT LIFE CYCLES

AND HOW BEST TO HELP STUDENTS LEARN ABOUT THEM.

WE START WITH THINGS

THAT BOYS AND GIRLS CAN LOOK AT, THAT THEY UNDERSTAND,

THAT THEY PROBABLY
HAVE QUESTIONS ABOUT --

ANY PARENT WILL TELL YOU THEY PROBABLY HAVE QUESTIONS ABOUT --

WHERE DID THE PETS,
THE CHILDREN,

THE BABIES COME FROM?

Woman: ONE OF THE VERY PRELIMINARY ACTIVITIES WAS

"WHAT CAME BEFORE" POSTERS.

AND WE JUST GAVE THE STUDENTS

SOME PICTURES OF ANIMALS
OR PLANTS,

JUST A RANDOM SELECTION
OF PICTURES,

AND WE ASKED THEM JUST TO DRAW WHAT CAME BEFORE.

AND THIS IS
A SWEET PEA ONE.

SWEET PEA
BEFORE THE LIMA BEAN,

AND THEN IT WAS
A BEAN PLANT.

ONE OF THE THINGS
KIND OF EMBEDDED

IN THIS INSTRUCTIONAL SEQUENCE
IS TO HAVE THE STUDENTS CHANGE,

EXPAND THEIR PERCEPTUAL WORLD.

INSTEAD OF JUST LOOKING
AT THE HERE AND NOW,

"WHAT WAS IT BEFORE" IS A WAY OF EXPANDING THEIR IDEAS

TO HAVE THEM LITERALLY THINK ABOUT, "WHAT WAS IT BEFORE?"

Boy: BEFORE, IT WOULD COME,
IT WOULD BE A BEETLE EGG

THEN LARVA, THEN PUPA,

AND THEN A BEETLE.

IF THEY HAVE A MISCONCEPTION ABOUT WHAT IT WAS BEFORE

OR THEY DON'T KNOW
WHAT IT WAS BEFORE,

HERE'S AN OPPORTUNITY FOR THEM TO ARTICULATE

OUT LOUD WHAT THEY THINK.

Bitterlich:
THEY CAME UP WITH A LOT

OF THINGS THAT WERE ACCURATE.

NOT TOTALLY ACCURATE,
BUT ACCURATE IN SOME CASES --

IN SOME CASES, TOTALLY WRONG --
AND WE JUST LEFT IT LIKE THAT.

WE EVEN POSTED THOSE POSTERS
IN THE HALL,

BECAUSE IT WAS THEIR THOUGHTS
OF SCIENCE OF WHAT CAME BEFORE.

Bybee: SO THE CHALLENGE
OF DESIGNING THE UNIT

WAS TO KEEP THINGS WITHIN
THEIR REALM OF UNDERSTANDING,

THINGS THEY COULD SEE
AND THEY COULD TALK ABOUT.

Bitterlich: BUT LOOK
AT THIS PUPA

FROM LEAH
AND NICOLE'S CHART.

WHAT DO YOU NOTICE DIFFERENT ABOUT THIS PUPA HERE?

Girl: IT'S STARTING
TO COME OUT.

YEAH.
WHAT CAN YOU SEE ON IT?

Bybee: THE BIG IDEA,
THAT WE WOULD HOPE

THEY DEVELOP OVER TIME,
IS SOME UNDERSTANDING

THAT THERE ARE
GREAT, GREAT DIVERSITIES.

THERE ARE DIFFERENT ORGANISMS, BUT THEY ALL HAVE LIFE CYCLES.

WE'LL RETURN
TO MARY BITTERLICH'S CLASSROOM

LATER IN THE SESSION.

OBSERVING LIFE CYCLES
IN THE CLASSROOM OR AT HOME

CAN FOCUS ATTENTION
ON THE QUESTION

OF HOW LIFE REPRODUCES.

WHICH QUESTIONS ABOUT REPRODUCTION *CAN* BE ANSWERED

BY SIMPLY OBSERVING
ANIMAL LIFE CYCLES,

AND WHICH CAN'T?

WHAT ABOUT EGGS?

LET'S VISIT ELEANOR ABRAMS
IN THE SCIENCE STUDIO

TO HEAR WHAT THE CHILDREN HAVE TO SAY ABOUT WHAT HAPPENS

BEFORE THE STRUCTURE
THEY THINK OF AS AN EGG APPEARS.

OKAY, WE'RE GOING TO LOOK AT SOME ANIMALS TODAY,

AND WHAT I WANT YOU TO DO IS LOOK AT THAT ANIMAL

AND THINK ABOUT
WHAT IT WAS BEFORE.

SO I'M GOING
TO BRING OUT THIS ANIMAL.

AND IF YOU CAN SEE,
THIS IS LUCKY.

LUCKY IS A COCKATIEL.

SO WHAT DO YOU THINK LUCKY WAS
BEFORE HE WAS AN ADULT BIRD?

A BABY BIRD.

Abrams: A BABY BIRD?

AN EGG.

Abrams:
AND BEFORE THAT, AN EGG.

THINK ABOUT
WHAT THE EGG WAS BEFORE.

DISCUSS IT WITH YOUR PARTNER.

AND WRITE A COUPLE IDEAS DOWN.

Boy: BEFORE, IT WAS AN EGG...
AND BEFORE THAT, IT WAS...

UM, MOM'S, MOM'S...

YEAH, BELLY.

BELLY, AND BEFORE THAT,
WAS DOT.

AND BEFORE THAT,
WAS NOTHING.

THAT'S A NICE
PROGRESSION.

WHAT DOES
A DOT MEAN?

LIKE, IT WAS JUST
A TINY DOT IN HIS MOM'S STOMACH.

COME ON, FIACHRA,
TELL ME WHAT THIS IS.

UH, BEFORE IT WAS A ADULT FISH,
IT WAS A TEENAGE FISH,

AND IT COULD'VE BEEN IN A LAKE, AND BEFORE THAT,

IT WAS A BABY FISH, AND I THINK
BEFORE THAT, IT WAS IN AN EGG.

AND THEN BEFORE THAT, IT WAS IN AN EGG IN ITS MOTHER'S STOMACH.

AND BEFORE THAT?

IT WAS
PARTS OF FISH.

Abrams: SO WHEN THE EGG IS

INSIDE THE MOTHER'S STOMACH,
IS IT ALIVE?

UH, NO.
HOW CAN AN EGG BE ALIVE?

I KNOW HOW AN EGG --

WHEN DOES THE BABY
FISH BECOME ALIVE?

WHEN IT'S BEING BORN?
I DON'T KNOW.

I THINK,
ONCE THEY WERE BORN,

THEY WERE,
THEY BECAME ALIVE.

OKAY.

CHILDREN HAVE PROBABLY
OBSERVED WHAT HAPPENS

AFTER AN EGG IS FERTILIZED.

THEY CAN TELL US
STORIES ABOUT THIS,

BECAUSE THEY HAVE SEEN
THESE LATER LIFE STAGES.

BUT A LIFE CYCLE
INVOLVES MUCH MORE

THAN CAN BE SEEN
WITH THE NAKED EYE.

STUDIES USING EARLY MICROSCOPES
ALLOWED SCIENTISTS

TO VIEW
THE BEGINNING STAGES OF LIFE,

THE POINT AT WHICH THE FIRST CELL OF A NEW LIFE IS CREATED,

THE POINT OF FERTILIZATION,
WHEN SPERM AND EGG UNITE.

USING A MICROSCOPE
TO VIEW DEEPER LEVELS

ALLOWED SCIENTISTS TO WITNESS

SOME OF THE KEY STRUCTURES
OF REPRODUCTION.

Narrator: AS SCIENTISTS CONTINUE TO LOOK FOR THE ANSWER

TO THE QUESTION,
"HOW DOES LIFE RENEW ITSELF,"

THEY LOOKED FIRST AT THE BASIC UNIT OF ALL LIFE -- THE CELL.

IN 1660, ROBERT HOOKE WAS
THE FIRST SCIENTIST

TO SEE A CELL.

DURING THE NEXT TWO CENTURIES,
THE MAGNIFYING ABILITY

OF THE MICROSCOPE
IMPROVED SIGNIFICANTLY,

AND RESEARCHERS GRADUALLY
BEGAN TO UNDERSTAND

THE STRUCTURE OF CELLS.

BY 1890, ROD-LIKE OBJECTS
WERE FIRST OBSERVED

IN THE NUCLEUS OF A CELL.

SCIENTISTS CALLED THESE STRUCTURES "CHROMOSOMES."

EVERY LIVING ORGANISM HAS
ITS OWN SET OF CHROMOSOMES,

FOUND IN ALMOST EVERY CELL.

THEY DISCOVERED
THAT THERE WERE 46 CHROMOSOMES

IN MOST HUMAN CELLS.

SCIENTISTS NOTED
THAT CHROMOSOMES

OCCURRED IN THE NUCLEUS
IN PAIRS.

EACH INDIVIDUAL CHROMOSOME
HAD A COUNTERPART.

SCIENTISTS ALSO OBSERVED
THAT EACH CHROMOSOME DOUBLED

TO FORM TWO STRANDS
BEFORE A CELL DIVIDED.

ONE STRAND FROM EACH CHROMOSOME

WAS SEEN TO BE PASSED
TO EACH DAUGHTER CELL.

EACH OF THE TWO CELLS
THUS RECEIVED

A FULL SET OF CHROMOSOMES.

THIS ANIMATION SHOWS US
WHAT FURTHER RESEARCH

REVEALED TO SCIENTISTS.

THEY FOUND THAT CHROMOSOMES
WERE MADE OF TWO TYPES

OF ORGANIC MOLECULES --
PROTEIN AND DNA.

BUT WHICH ONE CONTAINED
THE HEREDITARY MATERIAL?

A BREAKTHROUGH OCCURRED
WITH THE EXPERIMENTS

OF ALFRED HERSHEY
AND MARTHA CHASE IN 1952.

HERSHEY AND CHASE
STUDIED VIRUSES.

THEY PUT TO USE WHAT WAS KNOWN ABOUT THE STRUCTURE OF VIRUSES.

VIRUSES ARE MADE OF A PROTEIN COAT ON THE OUTSIDE,

SHOWN HERE IN GREEN,

AND DNA ON THE INSIDE,
SHOWN IN PURPLE.

TO REPRODUCE, VIRUSES ATTACH TO

AND TRANSFER VIRAL MATERIAL
INTO HOST CELLS.

THIS MATERIAL TAKES OVER
THE MACHINERY OF THE CELL

TO CREATE MORE VIRUSES.

AS THE VIRUSES BREAK
THE CELL OPEN TO ESCAPE,

THE CELL DIES.

HERSHEY AND CHASE REASONED
THAT IF THEY COULD DETERMINE

WHAT PART OF THE VIRUS
WAS TRANSFERRED,

THEY WOULD KNOW WHETHER
THE HEREDITARY MATERIAL

WAS DNA, PROTEIN,
OR PERHAPS BOTH.

IN SEPARATE BATCHES OF VIRUSES,
THEY TAGGED THE PROTEIN

WITH ONE KIND
OF MARKER SUBSTANCE,

AND TAGGED THE DNA
WITH ANOTHER.

THEY THEN ADDED THE VIRUSES
TO A CULTURE OF HOST CELLS.

WHEN THE VIRUSES
WITH TAGGED PROTEIN

INJECTED THEIR MATERIAL
INTO A CELL,

NONE OF THE MARKER SUBSTANCE
WAS FOUND IN THE CELL.

BUT IT *WAS* FOUND
IN THE VIRUS GHOSTS.

WHEN THE VIRUSES WITH TAGGED DNA INFECTED A CELL, HOWEVER,

THE MARKED SUBSTANCE
*WAS* OBSERVED INSIDE THE CELL,

AND *NOT* IN THE VIRUS GHOSTS.

FROM THIS EVIDENCE,
HERSHEY AND CHASE CONCLUDED

THAT DNA WAS THE MATERIAL
THAT ALLOWED VIRUSES

TO PASS ON
HEREDITARY INFORMATION.

MANY PEOPLE DON'T REALIZE
THAT VIRTUALLY EVERY CELL

IN EVERY LIVING ORGANISM
CONTAINS DNA,

FROM THE SMALLEST BACTERIUM
TO THE LARGEST TREE,

OR EVEN THIS KIWI FRUIT.

ALTHOUGH IT'S NOT POSSIBLE
FOR EVEN THE MOST POWERFUL

MICROSCOPE TO SEE THE STRUCTURE OF INDIVIDUAL MOLECULES OF DNA,

IT *IS* POSSIBLE FOR US TO SEE LARGE QUANTITIES OF DNA

IF IT IS CLUMPED TOGETHER.

A DEMONSTRATION CAN BE USED
IN THE CLASSROOM

TO EXTRACT DNA
FROM THE MANY MILLIONS OF CELLS

IN THE KIWI FRUIT.

Narrator: KIWI FRUIT IS CHOPPED AND MASHED INTO A FINE PULP.

SALT WATER IS PLACED
INTO A BEAKER,

TO WHICH LIQUID DETERGENT
IS GRADUALLY ADDED.

THIS IS
OUR DNA EXTRACTION SOLUTION.

THE PULP IS PLACED
INTO ANOTHER BEAKER,

TO WHICH OUR EXTRACTION SOLUTION IS CAREFULLY ADDED.

THE BEAKER IS HEATED.

THE MECHANICAL MASHING
AND HEATING OF THE KIWI FRUIT

BREAKS DOWN THE CELL WALLS.

DETERGENT HELPS TO BREAK DOWN THE ENVELOPE

SURROUNDING THE CELL NUCLEI.

AFTER ABOUT 15 MINUTES,
THE BEAKER IS REMOVED

FROM THE HEAT
AND PLACED IN AN ICE BATH

FOR ABOUT FIVE MINUTES,
WITH OCCASIONAL STIRRING.

A FUNNEL WITH A COFFEE FILTER
IS INSERTED INTO ANOTHER BEAKER.

THE COOLED EXTRACTION MIXTURE
IS GRADUALLY POURED

INTO THIS SIMPLE
FILTRATION SYSTEM.

A SMALL AMOUNT OF THE SOLUTION IS POURED INTO A TEST TUBE.

CHILLED ALCOHOL IS THEN
GENTLY POURED

DOWN THE SIDE OF THE TEST TUBE CONTAINING THE SOLUTION.

A SUBSTANCE IS SEEN
FORMING ALMOST INSTANTLY

IN THE ALCOHOL LAYER.

AFTER A FEW MINUTES,
IT GRADUALLY COAGULATES.

THIS SUBSTANCE
IS KIWI FRUIT DNA.

THE EXTRACTED DNA EVENTUALLY RISES TO THE SURFACE.

Zook: AT THE SURFACE
OF THE TEST TUBE IS A CLUMP

MADE OF SEVERAL MILLION
STRANDS OF DNA.

BUT AN INDIVIDUAL STRAND IS ACTUALLY EXTREMELY SMALL

AND CANNOT BE SEEN
EVEN WITH A POWERFUL MICROSCOPE.

IF WE WERE ABLE TO SEE A SINGLE STRAND OF THE KIWI FRUIT DNA,

ITS STRUCTURE WOULD LOOK
SOMETHING LIKE THIS.

DNA CAN BE EXTRACTED
FROM THE CELLS

OF ALL LIVING ORGANISMS.

WE CHOSE A KIWI FRUIT

BECAUSE OF THE RELATIVE
EASE OF EXTRACTING ITS DNA.

IT'S FANTASTIC, DOUG,
IT'S AMAZING TO THINK

THAT SOMETHING AS SMALL
AS A KIWI FRUIT

COULD CONTAIN DNA
THAT WE CAN ACTUALLY SEE.

SO WE NOW KNOW THAT VIRUSES
USE DNA TO PASS ON INFORMATION

TO BUILD NEW OFFSPRING.

AND WE HAVE ALSO SEEN
THAT ORGANISMS LIKE KIWI FRUITS

AND ANIMALS SUCH AS HUMANS
CONTAIN DNA.

BUT HOW DOES DNA HELP EXPLAIN
ANIMAL HEREDITY?

TO ANSWER THIS QUESTION,
WE MUST DIG A LITTLE DEEPER

AND CONTINUE TO MOVE BEYOND
WHAT CAN BE OBSERVED

ABOUT LIFE CYCLES
WITH THE NAKED EYE.

TODAY WE KNOW
THAT DNA RESEMBLES A STRUCTURE

CALLED A DOUBLE HELIX.

AND WE SEE PICTURES
OF IT EVERYWHERE.

IT LOOKS KIND OF LIKE
A SPIRAL STAIRCASE.

AND IT TOOK SCIENTISTS
A GREAT DEAL OF HARD WORK

TO REVEAL ITS STRUCTURE.

LET'S TAKE A CLOSER LOOK
AT THIS REMARKABLE MOLECULE.

Zook: THIS REPRESENTS
AN EXTREMELY SMALL PART

OF A STRAND OF DNA, THAT WOULD BE FOUND IN ONLY ONE CHROMOSOME.

IF THE DNA
IN THE 46 CHROMOSOMES

OF A SINGLE HUMAN CELL
WERE UNRAVELED

AND LAID OUT END TO END,
IT WOULD MEASURE APPROXIMATELY

TWO METERS IN LENGTH --
ABOUT MY HEIGHT.

LET'S IMAGINE THIS GOLF BALL

TO BE THE NUCLEUS OF A CELL.

IF WE PEEL BACK THE TOP LAYER,

WHICH REPRESENTS
THE NUCLEAR MEMBRANE,

WE CAN SEE AN EXTREMELY LONG,
TIGHTLY COILED RUBBER STRAND.

THE DNA IN THE NUCLEUS OF A CELL
IS ALSO PACKED VERY DENSELY.

IF THE NUCLEUS
IN ONE OUR CELLS

WERE ENLARGED TO THE SAME SIZE AS A GOLF BALL,

AND THE DNA INSIDE UNRAVELED
AND LAID END TO END,

IT WOULD BE OVER 30 MILES LONG.

THE LENGTH OF DNA
IN THE NUCLEUS OF A CELL

IS INDEED STAGGERING.

BUT HOW DOES ALL
OF THE INFORMATION

CONTAINED IN DNA
GET PASSED RELIABLY

FROM THE PARENT CELL
TO DAUGHTER CELLS

WHEN A CELL DIVIDES?

Narrator: THE BODY CELLS
IN A HUMAN BEING

CONTAIN 46 CHROMOSOMES
IN EACH NUCLEUS.

IF DAUGHTER CELLS
ARE TO CONTAIN ALL

OF THE HEREDITARY INFORMATION PRESENT IN THE PARENT CELLS,

THEN ALL OF THESE CHROMOSOMES MUST BE REPLICATED

BEFORE THE CELL DIVIDES.

HOW DOES THIS OCCUR?

THE STRUCTURE
OF THE DNA MOLECULE

IS A DOUBLE HELIX --

A TWISTED PAIR OF STRANDS CONNECTED ALONG ITS LENGTH.

THINK OF DNA AS A ZIPPER,
WITH TWO HALVES

CONNECTED BY INTERLOCKING TEETH.

THE ZIPPER UNZIPS,

AND ALONG THE LENGTH

OF EACH ORIGINAL HALF,
A NEW HALF IS ASSEMBLED.

WHEN THE PROCESS IS COMPLETE,

TWO IDENTICAL ZIPPERS
HAVE BEEN FORMED.

CHROMOSOME REPLICATION
HAPPENS LIKE THIS

TO EVERY CHROMOSOME
BEFORE A CELL DIVIDES.

FOR A SHORT TIME,
THE CHROMOSOMES CONTAIN

TWO IDENTICAL PARALLEL
DNA MOLECULES.

ONE OF THE TWO IS PASSED ON
TO EACH DAUGHTER CELL.

ALL OF THE INFORMATION
HAS NOW BEEN TRANSFERRED,

AND IS READY TO BE TRANSLATED
TO BUILD A NEW CELL.

SO THAT'S HOW
INDIVIDUAL CELLS REPRODUCE.

BUT HOW DO ANIMALS
PRODUCE OFFSPRING,

THAT START WITH ONE CELL --
THE FERTILIZED EGG --

BUT HAVE TWO DIFFERENT PARENTS?

LET'S RETURN
TO THE SCIENCE STUDIO

TO HEAR WHAT THE CHILDREN
HAVE TO SAY

ABOUT THE ROLE FOR EACH PARENT IN REPRODUCTION.

Abrams: SO HOW DOES THE DAD
PLAY A ROLE?

Leo: HE FERTILIZES THE EGG.

AND WHAT DOES FERTILIZATION
DO TO THE EGG?

IT MAKES THE BABY
COME OUT.

SO IT COULDN'T BE FERTILIZED,
BECAUSE THEY LAY THE EGG,

AND THEN IT HATCHES,
RIGHT?

'CAUSE, SO THEY DON'T REALLY
NEED DADS, DO THEY?

THEY DON'T NEED DADS.

Abrams: BIRDS?
ALL BIRDS, OR JUST THIS BIRD?

WELL, ALL BIRDS
DON'T NEED DADS,

BECAUSE THEY DON'T NEED
TO BE FERTILIZED.

SO THE MOM CAN LAY
THE EGG ON ITS OWN.

YEAH, SO IT'S A DOT, AND THEN
IT'S NOTHING, A DOT.

WHAT DO YOU THINK, BRYAN?
HOW DO YOU THINK ABOUT IT?

UM...UM...

I THINK THE SAME THING
THAT LEO THOUGHT,

BECAUSE IT DOES START
INTO A DOT,

AND THEN IT KEEPS ON EATING,
AND THEN, AND LIKE WHEN,

I THINK WHEN THE MOM EATS,
AND THEN LIKE THE EGG GETS FED,

AND THEN IT GROWS BIGGER
AND BIGGER AND BIGGER.

BUT BEFORE THAT,
IT'S NOTHING.

AND THEN, AND THEN BEFORE --
BUT WHEN IT'S EARLIER,

THEN IT BECOMES TO A DOT.

Abrams:
SO DO YOU AGREE WITH LEO

THAT THE MOMMY DOESN'T NEED
A DADDY TO MAKE A BABY?

UH, YEAH.

Leo: YEAH, BUT SHE MIGHT
NEED THE DAD TO, LIKE,

HELP HER
WITH THE BABY.

ONCE IT'S BORN?
YEAH.

GOOD.

Girl: I THINK FIRST,
THERE WAS NO BABY

IN THE MOTHER,
BUT THEN IT CAME TO BE

WHEN SHE GOT, LIKE,

A DIFFERENT GERM IN HER BODY
BESIDES HERS,

OR A DIFFERENT KIND
OF SOMETHING.

I THINK THAT MAYBE
AFTER SHE MATED?

CAN ANY BIRD MATE
WITH THE MOMMY BIRD?

NO,
IT HAS TO BE MALE.

HAS TO BE A MALE.
A MALE AND A FEMALE.

OKAY.

SO WHAT DO YOU THINK
THAT GERM IS?

DO WE ALWAYS HAVE
THAT GERM INSIDE US?

I DON'T THINK WE *ALWAYS*
HAVE THE GERM INSIDE US.

Grisham: ACCORDING
TO RESEARCH FINDINGS,

CHILDREN IN THE EARLY GRADES
OFTEN HAVE CONFUSIONS

ABOUT BASIC PARTS
OF A LIFE CYCLE.

DO YOUR STUDENTS THINK
THAT OFFSPRING

ARE ALREADY PRESENT
AND WAITING TO BE BORN?

WELL, DOUG, IT LOOKS LIKE
SOME OF THE CHILDREN

AREN'T TOO SURE ABOUT THE NEED FOR THEIR FATHERS.

CHILDREN DO HAVE IDEAS THAT
THE FATHER *SOMEHOW* PROVIDES

HELP TO THE MOTHER, OR HAS
A ROLE IN ACTIVATING THE EGG.

BUT WE HAVE SEEN
THAT SOME OFFSPRING

RESEMBLE THEIR FATHERS.

STILL OTHERS HAVE OBVIOUS TRAITS
FROM BOTH OF THEIR PARENTS.

IF THE FATHER PLAYS
NO ROLE IN PROVIDING

HEREDITARY INFORMATION,
HOW COULD THIS BE SO?

AN INFERENCE CAN BE MADE
THAT SPERM, THE MALE SEX CELL,

*DOES* CARRY
HEREDITARY INFORMATION

TO THE FERTILIZED EGG.

BUT ONE CAN WONDER, IF YOU LOOK MORE LIKE YOUR FATHER,

DO YOU GET
MORE CHROMOSOMES FROM HIM?

OR DO GIRLS, BEING FEMALE,
GET MORE CHROMOSOMES

FROM THEIR MOTHER?

THIS IS ANOTHER PART
OF THE PUZZLE OF REPRODUCTION.

WHAT CONTRIBUTION DO THE MALE AND FEMALE PARENTS MAKE

IN THE FERTILIZATION OF THE EGG?

Narrator: THE 46 CHROMOSOMES
IN A BODY CELL OF A HUMAN BEING

REPRESENT WHAT IS CALLED
THE HUMAN GENOME,

A LARGE POOL OF INFORMATION SPECIFIC TO HUMAN BEINGS.

THE INFORMATION FOR ALL
OF THE TRAITS OF A HUMAN

IS FOUND IN ITS GENOME.

AND VIRTUALLY EVERY BODY CELL
CONTAINS ALL 46 CHROMOSOMES --

THE ENTIRE HUMAN GENOME.

DIFFERENT TYPES OF ORGANISMS HAVE THEIR OWN UNIQUE GENOME.

COMPARED TO A HUMAN BEING,
WITH 46 CHROMOSOMES,

THE KIWI FRUIT GENOME
HAS 58 CHROMOSOMES.

IF CONTINUITY OF LIFE
IS TO OCCUR,

THE INFORMATION CONTAINED
IN THE GENOME MUST BE PRESENT

IN THE FIRST CELL FROM WHICH ALL OTHER CELLS ARISE --

THE FERTILIZED EGG.

BUT HOW DOES THIS WORK
WHEN TWO PARENTS --

EACH WITH THEIR OWN
FULL SET OF CHROMOSOMES --

FORM THE FIRST CELL?

A SIMPLIFIED WAY
OF LOOKING AT THIS

IS AS A PUZZLE OF NUMBERS.

LET'S LOOK AT A FRUIT FLY.

THE INFORMATION TO BUILD
A FRUIT FLY

IS PACKAGED IN ONLY EIGHT CHROMOSOMES.

ALL OF THIS INFORMATION
MUST BE CONTAINED

IN A FERTILIZED FRUIT FLY EGG.

IMAGINE IF THE FEMALE
DONATED EIGHT CHROMOSOMES,

AND THE MALE ALSO
DONATED EIGHT CHROMOSOMES.

THERE WOULD BE A TOTAL
OF 16 CHROMOSOMES

IN THE FERTILIZED EGG --

TWICE THE AMOUNT
OF INFORMATION REQUIRED.

IF THIS PROCESS
WERE TO CONTINUE,

THERE WOULD BE 32, 64,
THEN 128 CHROMOSOMES.

THAT'S TOO MUCH.

THE RESULT WOULD NOT
BE A FRUIT FLY.

THIS IS THE STUFF
OF MUTANT ALIEN MOVIES.

FOR ANY TYPE OF LIVING THING,

IF OFFSPRING ARE
TO RESEMBLE THEIR PARENTS,

SEXUAL REPRODUCTION
MUST MAINTAIN THE GENOME

BETWEEN GENERATIONS.

SCIENTISTS EARLY ON
OBSERVED THAT SEX CELLS --

THE SPERM AND EGGS --
CARRIED ONLY ONE-HALF

AS MANY CHROMOSOMES AS THE CELLS FROM WHICH THEY WERE FORMED --

ONE MEMBER
OF EACH CHROMOSOME PAIR.

WHEN SPERM FERTILIZES EGG,

THESE TWO COUNTERPARTS UNITE.

ALL OF THE INFORMATION REQUIRED
TO BUILD THE ORGANISM

IN NOW PRESENT AND ACCOUNTED FOR IN THESE EIGHT CHROMOSOMES.

SEX CELLS ARE FOUND ONLY

IN AN ORGANISM'S
REPRODUCTIVE ORGANS,

AND NOT FOUND IN ANY OTHER PART
OF AN ORGANISM.

THEY ARE THE ONLY CELLS
DIRECTLY INVOLVED

IN THE PASSING ON OF INFORMATION

FROM ONE GENERATION
TO FUTURE GENERATIONS.

SO, CONTRARY TO WHAT
THE CHILDREN THOUGHT,

THE MALE DOES HAVE A ROLE
IN THE PASSING ON

OF HEREDITARY INFORMATION,
SUPPLYING HALF

OF THE GENETIC INFORMATION
REQUIRED TO FORM OFFSPRING.

THE OTHER HALF COMES
FROM THE FEMALE.

IN FRUIT FLIES
AND ALMOST ALL OTHER ANIMALS,

INFORMATION FROM BOTH SEXES
IS REQUIRED

FOR SUCCESSFUL REPRODUCTION.

BUT THERE ARE SPECIES
THAT REPRODUCE ASEXUALLY --

THAT IS,
WITHOUT TWO DIFFERENT SEXES.

IN THESE ORGANISMS, THE GENOME MUST ALSO BE MAINTAINED

BUT INSTEAD OF INFORMATION BEING TRANSFERRED FROM TWO PARENTS,

ALL THE INFORMATION

IN ONE GENERATION

IS PASSED ON TO THE NEXT.

AN AMAZING THING ABOUT ANIMALS

AND OTHER
MULTICELLULAR ORGANISMS

IS THAT THEY ALL START
FROM JUST ONE SINGLE CELL.

BUT HOW DO
THE MANY DIFFERENT PARTS

OF THESE ORGANISMS
FORM FROM THE FIRST CELL?

WE WENT TO A LOCAL POND, TO LOOK FOR SOME WATER SNAIL EGGS,

WHICH ARE COMMONLY FOUND
UNDERNEATH FLOATING WOOD

IN POND WATER
IN THE LATE SPRING.

ON A MICROSCOPE SLIDE,

AMONG THE REST OF THE POND LIFE,
CAN BE SEEN THE SNAIL EGGS.

HERE WE CAN SEE
A SINGLE FERTILIZED EGG.

ON THE DAY THAT WE COLLECTED IT,

WE SEE VERY LITTLE,
APART FROM AN EGG WALL

SURROUNDING A TIGHTLY PACKED

COLLECTION OF FLOATING CELLS.

BUT BY THE FOURTH DAY,
THE NUMBER OF CELLS

HAS CLEARLY MULTIPLIED.

A CLOSER LOOK SHOWS US
THE OUTLINES

OF A NUMBER OF INDIVIDUAL CELLS.

AS WE WATCH
THE EGG'S DEVELOPMENT

OVER THE NEXT FOUR DAYS,
WE SEE IT GROW

FROM A BALL OF CELLS

TO A BARELY RECOGNIZABLE OUTLINE

OF A WATER SNAIL.

BY THE END OF THE WEEK,
WE'RE ABLE

TO SEE ITS EYES, SHELL,
AND ITS BEATING HEART.

A COUPLE OF DAYS LATER,

THE SNAIL BREAKS FREE
FROM ITS EGG SAC,

TO JOIN THE REST
OF THE SNAIL POPULATION.

BUT HOW DO
THESE MANY DIFFERENT PARTS

OF AN ORGANISM FORM
FROM THE FIRST CELL?

WE MET WITH
DR. SIGAL KLIPSTEIN,

WHOSE RESEARCH INTEREST
IS IN THE FIELD

OF REPRODUCTIVE TECHNOLOGIES
AND MEDICAL ETHICS,

AND TALKED WITH HER
ABOUT WHAT HAPPENS TO CELLS

AFTER THEY ARE FERTILIZED.

THIS ONE CELL MAKES
A WHOLE ORGANISM,

A WHOLE OFFSPRING,
A WHOLE CHILD,

A WHOLE COW, A WHOLE CAT.

AND THIS IS INTERESTING,

AND WE'RE LEARNING MORE AND MORE ABOUT HOW THIS HAPPENS.

SO THAT'S HOW IT STARTS,
TO DIVIDE INTO TWO CELLS

AND THEN FOUR AND SO ON,
BUT WHAT EVENTUALLY HAPPENS

IS THAT SOME OF THOSE CELLS
WILL BECOME BRAIN CELLS

AND OTHERS WILL BECOME
HEART CELLS.

THE FUNCTION OF AN EGG
IS TO START, IN A SENSE,

TO JUMP-START THE PROCESS
OF REPRODUCTION, IS TO DIRECT

THE EVENTS
THAT LEAD TO EARLY DEVELOPMENT,

TO TELL THE GENES
THAT ARE NECESSARY

IN EARLY DEVELOPMENT
TO TURN ON.

AND THEN ONCE THOSE GENES
TURN ON,

THEY DIRECT OTHER GENES
AND TELL THE EGG CELL,

THE FERTILIZED EGG, FOR EXAMPLE,
TO DIVIDE.

AND THEN THEY TELL,
AND THEN CERTAIN GENES

THEN DIRECT OTHER DEVELOPMENTS IN THE EARLY EMBRYO,

FOR EXAMPLE, THE HEART,
TO BEAT,

AND THE SKIN TO START
TO DEVELOP,

AND THE SPINAL CORD,
AND THE NERVOUS SYSTEM.

SO THE EGG

IS THE INITIAL STIMULUS

THAT SOMEHOW DIRECTS THE DNA
TO START FUNCTIONING.

AND WE DON'T KNOW
QUITE HOW THIS HAPPENS.

IN EACH CELL,
WHILE ALL THE GENES ARE PRESENT,

SOME OF THEM ARE TURNED ON,
AND SOME OF THEM ARE TURNED OFF.

AND WHILE WE DON'T KNOW EXACTLY
WHAT TURNS GENES ON AND OFF,

WE'RE STUDYING THIS EVERY DAY.

WE DO KNOW THAT EVERY CELL
HAS DIFFERENT GENES

THAT ARE TURNED ON
AND TURNED OFF,

AND THIS DETERMINES
THE CHARACTERISTICS OF THAT CELL

AND THAT DETERMINES
THE FUNCTION OF THE CELL.

AND THAT'S WHY ALL THESE CELLS
THAT STARTED OUT FROM ONE CELL

THAT DIVIDED EXACTLY
INTO TWO CELLS THAT LOOKED VERY,

LOOKED EXACTLY IDENTICAL,
EVENTUALLY LOOK VERY DIFFERENT

AND FORM A WHOLE ORGANISM.

AFTER AN EGG IS FERTILIZED,
IT BEGINS TO DIVIDE AND FORM

THE EARLIEST DEVELOPMENTAL STAGES IN AN ANIMAL'S LIFE,

CALLED AN EMBRYO.

LET'S ADD THIS
TO OUR ANIMAL LIFE CYCLE.

ADULT, SEX CELLS,

FERTILIZED EGG, AND EMBRYO.

BUT HOW DOES THIS ALIGN
WITH WHAT IS GOING ON

WITH CHROMOSOMES,
THE CARRIERS OF DNA?

AT THE CHROMOSOMAL LEVEL,
IN ADULT CELLS,

BOTH MEMBERS OF EACH PAIR
OF CHROMOSOMES EXIST.

ONE MEMBER OF EACH
OF THESE PAIRS OF CHROMOSOMES

IS PASSED TO THE SEX CELLS.

UPON FERTILIZATION, THE TWO COPIES OF EACH CHROMOSOME

ARE REUNITED
IN THE FERTILIZED EGG.

CELL DIVISION TO FORM THE EMBRYO OCCURS WITH ALL SUBSEQUENT CELLS

CONTAINING THE FULL SET

OF CHROMOSOMES.

THE PASSING ON
OF HEREDITARY INFORMATION

FROM ONE GENERATION
TO THE NEXT

IS COMPLETED THROUGH A VERY ORDERLY AND PREDICTABLE PROCESS.

BUT YOU HAVE PROBABLY
HEARD NEWS STORIES

OF WAYS THAT SCIENTIST
ARE EXPERIMENTING

WITH BYPASSING
THE NORMAL LIFE CYCLE.

DR. KLIPSTEIN SPOKE TO US
ABOUT THE PROCESS OF CLONING.

A CLONE IS
A GENETICALLY IDENTICAL COPY

OF A SINGLE INDIVIDUAL,

IN THIS CASE,
CREATED IN A LABORATORY.

THE CLONE
DOESN'T ACTUALLY HAVE PARENTS.

A CLONE IS A REPRODUCTION
OF ONE CELL OF AN ORGANISM.

SO WHAT WE DO IS WE TAKE

AN EGG FROM A FEMALE,
AND WE REMOVE

ALL OF THE GENETIC MATERIAL --

WE REMOVE ALL OF THE DNA
FROM THAT EGG.

AND INSTEAD, WE PUT THE DNA
FROM AN ADULT ANIMAL.

AND THAT DNA THEN
STARTS TO GROW,

AND THAT EGG, THAT HAS NO GENETIC INFORMATION OF ITS OWN,

JUST USES THE GENETIC INFORMATION OF THE ADULT,

AND WITH THAT,
STARTS TO FORM AN EMBRYO,

AND IF THAT EMBRYO
IS PLACED IN A UTERUS,

IT CAN GROW INTO AN ADULT.

Narrator: A BREAKTHROUGH OCCURRED IN CLONING RESEARCH

IN 1997 WITH THE CLONING
OF THE FIRST MAMMAL,

A SHEEP NAMED DOLLY.

DOLLY WAS MADE BY TAKING
THE EGG CELLS FROM A SHEEP,

TAKING OUT ALL OF THEIR DNA,

AND THEN PUTTING IN THE DNA

FROM THE MAMMARY GLANDS
OF AN ADULT SHEEP.

THERE WERE ALMOST 300 EGGS
THAT WERE INJECTED

WITH THE DNA OF AN ADULT,
AND ONLY ONE OF THEM ENDED UP

BEING BORN INTO THE BABY CALF,
WHICH WAS DOLLY.

CLONING IS AT THE MOMENT
A VERY INEFFICIENT SCIENCE.

WE NEED TO MAKE
SEVERAL HUNDRED ATTEMPTS

TO CLONE AN ANIMAL
BEFORE WE ARE SUCCESSFUL.

CLONING IS VERY IMPORTANT
IN ANIMAL RESEARCH

BECAUSE WHAT YOU CAN DO IS YOU CAN CLONE A MOUSE, FOR EXAMPLE,

AND YOU CAN HAVE HUNDREDS
OF EXACTLY IDENTICAL COPIES

OF A MOUSE, AND THEN YOU MIGHT WANT TO TEST CERTAIN DRUGS

AND YOU COULD TEST THOSE DRUGS

ON ALL THESE
EXACTLY IDENTICAL MICE.

CLONING HAS BEEN
VERY CONTROVERSIAL,

BECAUSE IT'S NOT AT ALL CLEAR THAT WE *SHOULD* BE CLONING.

IN A SENSE, CLONING
IS ALLOWING HUMANS TO INTERFERE

WITH THE NORMAL REPRODUCTIVE PROCESSES THAT OCCUR.

AND IT'S THE FIRST TIME,
REALLY, IN HISTORY, WHERE

WE'VE BEEN ABLE TO MAKE
AN OFFSPRING,

AN EMBRYO, THAT HAS ONLY
THE CONTRIBUTION

OF ONE PARENT OR THE OTHER.

FOR EXAMPLE, YOU MIGHT HAVE
A COW THAT MAKES MORE MILK

THAN ANY OTHER COW, AND YOU MIGHT CLONE A HUNDRED COPIES

OR A THOUSAND COPIES
OF THAT COW.

IT MAY BE THAT
YOU LIKE THIS COW SO MUCH

THAT NOW ALL THE COWS
IN ONE SPECIFIC COUNTRY

ALL LOOK EXACTLY IDENTICAL
TO THIS ONE COW.

BUT NOW, YOU HAVE A LOT OF MILK BEING PRODUCED

BY THIS COW,
AND THIS IS GREAT,

BUT MAYBE A DISEASE COMES ALONG,
AND THIS DISEASE

ONLY KILLS
A CERTAIN TYPE OF COW.

BUT NOW ALL YOUR COWS
ARE EXACTLY THE SAME,

SO THIS DISEASE WOULD WIPE OUT *ALL* YOUR COWS.

THERE'S NO VARIATION,
AND VARIATION IS IMPORTANT

IN THE ANIMAL KINGDOM,

BECAUSE SINCE WE DON'T KNOW
HOW TO PREDICT

WHICH DISEASES WILL COME ALONG,

OR WHICH ENVIRONMENTAL FACTORS
WILL COME ALONG,

WE KNOW THAT IF EVERY COW
IS A LITTLE BIT DIFFERENT

FROM ITS NEIGHBOR COW,
SOME WILL MAKE IT

THROUGH THE DISEASE
AND SOME WON'T.

IF THEY'RE ALL EXACTLY IDENTICAL, YOU COULD WIPE OUT

ALL OF THE COWS WITH ONE DISEASE

OR WITH ONE CHANGE IN TEMPERATURE OR WITH ONE CHANGE

IN THE TYPE OF GRASS THAT THEY'RE EATING.

SO DIVERSITY IS ACTUALLY
VERY IMPORTANT.

WE MAY, AS HUMAN BEINGS,
THINK THAT WE CAN MAKE

THE BEST SPECIES --
THE BEST COW, THE BEST CAT.

WE MAY BE WRONG,
AND IF WE'RE WRONG,

THAT'S A VERY,
VERY LARGE RISK TO TAKE,

BY DECREASING DIVERSITY,

AND THERE'S, IN A SENSE,
NO GOING BACK FROM THAT PROCESS.

SO CLONES REALLY
DON'T HAVE PARENTS,

ALTHOUGH THEY DO COME
FROM THE BODY CELL OF AN ADULT.

THIS IS UNLIKE THE HUMAN
AND FRUIT FLY EXAMPLES

WE HAVE CONSIDERED,
WHERE TWO PARENTS

AND THEIR SEX CELLS
ARE INVOLVED.

BOTH CLONES
AND THE AVERAGE ANIMAL, HOWEVER,

DEVELOP FROM AN EGG.

Grisham: THE CONTINUITY OF LIFE

INVOLVES A MUCH MORE SOPHISTICATED PROCESS

THAN MERE PHOTOCOPYING.

WHAT WE ARE LOOKING FOR
IS AN ANALOGY

WHERE A PARENT
CONTAINS WITHIN ITSELF

INFORMATION TO BUILD
ONE OF ITS OWN KIND.

REPRODUCTION INVOLVES
PASSING THIS INFORMATION

TO A NEW INDIVIDUAL THAT USES IT TO START UP AND FUNCTION.

PERHAPS IT'S CLOSER
TO A COMPUTER WITH SOFTWARE

THAT CAN BE TRANSFERRED
TO ANOTHER COMPUTER

THAT THEN RUNS
USING THE SOFTWARE.

IN FACT, WE COULD HAVE
AS MANY COMPUTERS AS WE WANT

RUNNING FROM THE SAME SOFTWARE.

Zook: MAYBE THAT IS BETTER,
BUT THE NEW COMPUTER

WOULD HAVE TO BUILD ITSELF
FROM PARTS

THAT ARE AVAILABLE
IN ITS ENVIRONMENT,

AND WOULD ALSO NEED TO TEAM UP WITH ANOTHER COMPUTER.

LET'S CONTINUE WITH OUR STUDY
OF THE ANIMAL LIFE CYCLE.

WHAT HAPPENS AFTER THE EMBRYO?

WE ARE NOW AT A POINT
IN A LIFE CYCLE

THAT CAN OFTEN BE OBSERVED
IN THE CLASSROOM.

WE'VE MOVED FROM
THE MICROSCOPIC WORLD

OF SEX CELLS,
FERTILIZED EGGS, AND EMBRYOS,

TO THE MACROSCOPIC LEVEL
OF AN IMMATURE ORGANISM.

LET'S RETURN TO OUR FEATURED CLASSROOM IN LAKEWOOD, COLORADO,

WHERE MARY BITTERLICH'S
THIRD GRADE STUDENTS

ARE NOW CONTINUING
THEIR INVESTIGATION

OF THE LIFE CYCLE
OF THE DARKLING BEETLE.

EACH TEAM HAD
A JAR OF CREATURES,

AND THEIR CREATURES
WERE GIVEN TO THEM,

AND WE ASKED THEM
TO PUT THEM ON A PLATE

AND SORT THEIR CREATURES.

AND INSIDE WERE
SOME ADULT BEETLES.

THEY ALSO HAD
SOME MEALWORMS IN THEM.

AND THERE WAS ALSO
SOME PUPAE IN THEM.

OF COURSE, THEY HAD NO IDEA WHAT SOME OF THESE CREATURES WERE.

AND THEY DID SORT THEM,
NATURALLY.

AND AS A CLASS,
THEY CAME TO THE CONCLUSION

THAT THEY WERE WORMS, BEETLES, AND DEAD THINGS -- THE PUPA

BEING THE DEAD THINGS, BECAUSE THEY DIDN'T KNOW WHAT IT WAS.

Girl: WELL, WHEN WE STARTED,
THE WORM, THIS, THE WORM JAR

WAS A WORM, AND IT,
THEN IT TURNED INTO THIS,

LIKE, DEAD THING.

THIS ONE,
THIS IS THE BEETLE JAR.

AND IT'S BEEN BEETLES.

AND THEN I GAVE THEM
THREE BABY FOOD JARS,

AND THEY LABELED THE JARS
WITH THE DATE

AND WHAT THEY CALLED THEM
ON THEM.

Girl: ON THE 4th OF APRIL,
THERE WAS TWO BEETLES,

TWO WORMS, AND TWO DEAD THINGS.

AND ON THE 11th,
THEY ATE A LOT,

AND ON THE 15th,
THEY WERE VERY ACTIVE.

WITHIN A COUPLE OF DAYS,
WE ACTUALLY HAD A COUPLE

OF THE PUPAS
CHANGE INTO BEETLES,

AND THE KIDS WERE ASTOUNDED.

THIS PUPA IS
FROM ALEX AND JACOB'S JAR.

WHAT DO YOU NOTICE DIFFERENT ABOUT THIS PUPA HERE?

IT'S STARTING TO COME OUT.

YEAH!
WHAT CAN YOU SEE ON IT?

YOU CAN SEE
THE LEGS AND THE HEAD.

SO THIS PUPA IS CLOSE
TO EMERGING INTO A...

BEETLE.

A BEETLE, THAT'S RIGHT.

AND THIS BEETLE,
YOU'VE SEEN THIS BEETLE

FROM THE MEALWORM STAGE
TO THE PUPA STAGE TO THE BEETLE.

THE WORM TURNED
INTO THE DEAD THING,

BUT THEN THE DEAD THING
TURNED INTO THE BEETLE.

THAT WAS VERY SURPRISING.

AND TODAY I'M GOING TO BE HAVING YOU MAKE A LIFE CYCLE PLATE

OF THE DARKLING BEETLE

THAT WE HAVE
IN THE BACK OF OUR ROOM.

WHO THINKS THEY CAN REMEMBER
THE LIFE CYCLE,

AND THE ORDER THAT YOU'RE GOING TO PUT THEM IN ON THE PLATE?

MEALWORM...EGG --
I MEAN, PUPA...AND THEN BEETLE.

I WANT YOU TO WORK TOGETHER
WITH YOUR GROUPS,

AND I WANT YOU TO TALK ABOUT
HOW YOU'RE GOING

TO CREATE YOUR PLATE
TO SHOW THE LIFE CYCLE

OF THIS DARKLING BEETLE
THAT YOU HAVE WITH YOU.

THIS IS THE PUPA.
THEN MEALWORM.

IT GOES, EGG, MEALWORM...

PUPA...

PUPA, THEN WE GO
TO A BEETLE.

Girl: I THINK
THE EGG CAME FIRST,

THEN MEALWORM,
THEN PUPA?

YEAH.

AND THEN
THE DARKLING BEETLE.

YEAH.

Bitterlich: I'M GOING TO ASK YOU
TO COME JOIN ME ON THE FLOOR.

I'VE TAKEN MOST OF YOUR PLATES,
I HAVE A FEW MORE LEFT,

BUT I'VE TAKEN MOST OF YOUR PLATES THAT YOU MADE TODAY,

AND WE'VE DONE THE CYCLE
FROM EGG TO...

MEALWORM...

TO...PUPA...

TO...DARKLING BEETLE.

NOW, FROM THIS, I CREATED A NEW SPIRALING CYCLE, LIFE CYCLE.

WHY DID I CREATE THEM
LIKE THIS, IN A SPIRAL,

INSTEAD OF JUST A NICE CIRCLE?

WHY DID I DO THAT?
RYAN?

BECAUSE AFTER IT'S TO THE ADULT,
IT HAS THE EGG,

AND THEN IT STARTS ALL OVER.

WE WANT THEM TO UNDERSTAND THAT A LIFE CYCLE ISN'T CIRCULAR,

BUT THAT IT'S SPIRAL, BECAUSE
ONE ADULT ANIMAL OR INSECT

FEEDS INTO THE EGG, OR THE START OF A NEW ANIMAL OR INSECT,

NOT INTO ITSELF.

IF WE HAD THIS SPIRAL, HERE --
IF SOMETHING HAPPENED

TO THIS BEETLE RIGHT HERE --
SAY HE GOT SQUASHED OUTSIDE --

ALEX ACCIDENTALLY
STEPPED ON HIM, OOPS.

WHAT WOULD HAPPEN TO ALL THESE?

THEN IT WOULD JUST STOP
THE LIFE CYCLE,

AND IT'S SORT OF LIKE
BEING NOT CREATED.

Bitterlich: EXCELLENT.
GOOD EXPLANATION.

SO IN OTHER WORDS,
IF THERE'S NOT AN ADULT

THAT CREATES A NEW EGG,
OF *ANY* KIND OF ANIMAL,

THEN HOW
DOES IT CONTINUE ON?

Zook: ACCORDING TO RESEARCH
BY DR. DRIVER, MANY CHILDREN

HAVE DISPARATE IDEAS ABOUT
THE CONTINUITY OF LIFE,

AND THINK THAT LIFE
CAN BE TURNED ON AND OFF

AT THE VARIOUS STAGES.

DO YOU THINK YOUR STUDENTS
MIGHT HAVE SIMILAR CONFUSIONS?

MARY BITTERLICH RAISED
AN INTERESTING POINT.

IN A LOT OF TEXTBOOKS, A CIRCLE REPRESENTS THE LIFE CYCLE.

BUT ACTUALLY, IT *IS* A SPIRAL.

THE DARKLING BEETLE IS ONE EXAMPLE OF AN ANIMAL LIFE CYCLE

THAT IS TYPICAL OF MANY INSECTS.

THE IMMATURE PHASES,

INCLUDING A LARVA AND A PUPA,

RESULT FROM METAMORPHOSIS --

DRAMATIC CHANGES
DURING EARLY DEVELOPMENT.

AN IMMATURE STAGE IS
ALL THAT IS LEFT

TO COMPLETE
OUR ANIMAL LIFE SPIRAL,

WITH THE GENERAL PATTERN BEING MALE AND FEMALE ADULTS

THAT PRODUCE SPERM AND EGG,

THAT THEN UNITE
TO FORM A FERTILIZED EGG.

THE FERTILIZED EGG
DEVELOPS INTO AN EMBRYO.

THERE MAY BE ONE OR MORE IMMATURE STAGES

BEFORE THE ADULT STAGE.

THE ADULT STAGE BEGINS
AT THE POINT

WHEN AN ANIMAL CAN REPRODUCE.

LET'S TAKE A LOOK
AT SOME OTHER EXAMPLES

FROM THE ANIMAL KINGDOM,

AND SEE HOW THE GENERAL LIFE CYCLE PATTERN CAN BE APPLIED.

Narrator: DEPENDING
UPON THE ENVIRONMENT

THAT AN ORGANISM LIVES IN,

VARIOUS METHODS OF FERTILIZATION
ARE USED IN THE PROCESS

OF SEXUAL REPRODUCTION.

EXTERNAL FERTILIZATION OCCURS OUTSIDE AN ANIMAL'S BODY.

MANY AQUATIC ANIMALS REPRODUCE SEXUALLY WITHOUT EVER MEETING.

A FISH IS A GOOD EXAMPLE
OF AN ANIMAL THAT RELEASES EGGS

THAT ARE FERTILIZED
OUTSIDE THE FEMALE'S BODY.

THESE FERTILIZED EGGS DEVELOP AND HATCH INTO SWIMMING LARVAE,

WHICH GROW TO BECOME SMALL FISH
WITH BODIES SIMILAR

TO THOSE OF THEIR PARENTS.

FROGS AND TOADS ALSO LAY EGGS EXTERNALLY IN WATER,

AND THESE EGGS
ARE ALSO FERTILIZED

OUTSIDE THE BODY OF THE FEMALE.

INSIDE EACH GELATINOUS EGG,

AN EMBRYO DEVELOPS
INTO A TADPOLE.

THE TADPOLE HATCHES
OUT OF THE EGG

AND BEGINS TO DEVELOP
INTO A POLLIWOG.

THE IMMATURE FROG
MATURES INTO AN ADULT.

ANOTHER FORM OF FERTILIZATION

IS KNOWN AS
INTERNAL FERTILIZATION.

MANY LAND-DWELLING ANIMALS

HAVE DEVELOPED WAYS
FOR FERTILIZATION

TO TAKE PLACE
INSIDE THEIR BODIES.

BIRDS' EGGS
ARE FERTILIZED INTERNALLY.

AS THE FERTILIZED EGG
TRAVELS DOWN

THE FEMALE'S REPRODUCTIVE SYSTEM,

THE EGGSHELL
IS SECRETED AROUND IT.

THIS EGGSHELL PROVIDES A HARDENED, WATERPROOF ENVIRONMENT

FOR THE DEVELOPING EMBRYO.

THE EMBRYO DEVELOPS
INSIDE THE EGG,

INTO AN IMMATURE VERSION
OF THE ADULT,

BEFORE BREAKING FREE.

IN A SIMILAR WAY TO THE BIRDS,

REPTILES LAY LEATHERY EGGS
ON LAND,

AFTER THEY ARE FERTILIZED INTERNALLY.

THE MAMMAL'S LIFE CYCLE

IS RELATIVELY SIMPLE.

MAMMALS DEVELOP
FROM A FERTILIZED EGG

INTO AN EMBRYO.

AFTER THE MAMMAL EGG
IS FERTILIZED,

IT IS IMPLANTED
INTO THE MOTHER'S BODY.

THIS EMBRYO REMAINS INSIDE
THE FEMALE'S BODY TO DEVELOP,

RECEIVING NUTRITION
FROM ITS MOTHER.

AT BIRTH, BABY MAMMALS
ARE IMMATURE VERSIONS

OF THE ADULT FORM.

SIMILARITIES WITHIN ALL OF THESE LIFE CYCLES ARE REMARKABLE.

IN EACH, A FERTILIZED EGG
DEVELOPS INTO AN EMBRYO

INSIDE A FLUID-FILLED SAC,

THE EGG.

THIS IS TRUE
WHETHER IT IS A FISH,

FROG, BIRD, REPTILE, OR MAMMAL.

IT IS ONLY AFTER THIS STAGE
IN THE LIFE CYCLE THAT ANIMALS

BEGIN TO RESEMBLE THE COUNTLESS SPECIES THAT WE SEE.

IT'S TIME TO CATCH UP
WITH "BOTTLE BIOLOGY."

PAUL WILLIAMS WILL INTRODUCE US
TO A SYSTEM

IN WHICH YOU CAN BRING
BOTH ANIMAL AND PLANT

LIFE CYCLES TOGETHER
IN THE CLASSROOM.

HELLO, WELCOME BACK
TO "BOTTLE BIOLOGY."

OUR FOUR SYSTEMS
ARE WELL UNDERWAY.

LET'S CHECK IN
AND SEE WHAT'S HAPPENING.

IN THE TERRAQUA SYSTEM,
THE SEEDS HAVE SPROUTED.

LOOK CLOSELY, AND SEE SOWBUGS
SCURRYING IN THE LEAVES

AND EARTHWORMS BURROWING
AROUND THE ROOTS.

THE PLANT AND ANIMAL KINGDOMS
ARE CERTAINLY

WELL REPRESENTED HERE.

AS WE GO,
WE'LL FOCUS ON LIFE FORMS

IN OTHER KINGDOMS AND DOMAINS.

IT'S AMAZING HOW FAR THE FIELD
POPULATION HAS COME

IN JUST A FEW DAYS.

CAN YOU SEE SOME DIFFERENCES
BETWEEN INDIVIDUAL PLANTS NOW?

WE'LL NEED TO
THIN THE SEEDLINGS OUT

TO PREPARE FOR AN EXPERIMENT
WE'LL DO LATER, SO STAY TUNED!

THE ECOCOLUMN
IS A MINIATURE ECOSYSTEM

WHERE LIVING THINGS
INTERACT WITH EACH OTHER

AND THE PHYSICAL
AND CHEMICAL ENVIRONMENT.

CHANGES IN THE ENVIRONMENT
ARE OFTEN BROUGHT ABOUT

BY LIVING THINGS.

WE'LL TRACK CHANGES BY GATHERING

BASELINE DATA NOW,

LIKE NUTRIENT LEVELS
IN THE WATER AND SOIL.

TODAY'S TOPIC IS LITERALLY
BROUGHT TO LIFE

IN THE BRASSICA
AND BUTTERFLY SYSTEM.

THESE TWO ORGANISMS
HAVE LIFE CYCLES

THAT ARE CLOSELY INTERTWINED.

THE LEAVES OF THE BRASSICA

ARE WHERE THE CABBAGE WHITE BUTTERFLY LAYS ITS EGGS.

THE EGGS HAVE NOW HATCHED,

AND YOU WILL SEE HUNGRY LARVAE
FEEDING ON THE PLANT.

THE LARVAE FEED LIKE CRAZY,

MOLTING FIVE TIMES
BEFORE BECOMING PUPAE.

SO FAR, IT MAY SOUND LIKE
A ONE-SIDED RELATIONSHIP

WHERE THE BUTTERFLY GETS
THE BETTER DEAL.

SOON YOU'LL FIND OUT

HOW THE BRASSICA BENEFITS
FROM THE BUTTERFLY.

BE SURE TO VISIT
"BOTTLE BIOLOGY" ON OUR WEBSITE

TO FIND ACTIVITIES YOU CAN DO WITH YOUR SYSTEM,

AND TO KEEP TRACK
OF WHAT'S GOING ON WITH OURS.

THANK YOU, PAUL.

THE BUTTERFLY IN THIS SYSTEM
IS AN INSECT WITH A LIFE CYCLE

SIMILAR TO THE DARKLING BEETLE
THAT THE STUDENTS

WERE WORKING WITH
IN OUR FEATURED CLASSROOM.

IN THIS CASE,
THE BUTTERFLY'S LIFE CYCLE

IS INTIMATELY CONNECTED TO
THE PLANT THAT IT LIVES ON.

IN THE NEXT SESSION,

WE WILL BE INVESTIGATING
PLANT LIFE CYCLES.

IN OUR SYSTEM, WE CAN SEE
THAT THE TINY EGGS

HAVE HATCHED
INTO THE FIRST LARVAL STAGE.

YOU CAN ALSO SEE PUPAE
FROM WHICH BUTTERFLIES

ARE ABOUT TO EMERGE.

IT WILL BE FUN
TO KEEP AN EYE ON THIS.

SO LET'S REVIEW
WHAT WE HAVE LOOKED AT

AT TODAY'S SESSION
IN A SLIGHTLY DIFFERENT WAY.

THE STUDY OF LIFE CYCLES
IS ACTUALLY A STUDY

OF MANY DIFFERENT
LEVELS OF ORGANIZATION.

THE ANSWER TO OUR QUESTIONS ABOUT WHAT ENSURES

THE CONTINUITY OF LIFE
BEGINS WITH DNA,

INVISIBLE TO THE NAKED EYE,

AT THE LEVEL
OF ORGANIC MOLECULES.

SPERM AND EGG ARE THE CELLS
THAT ARE CRITICAL

TO SEXUAL REPRODUCTION
IN ANIMALS.

THEY FORM THE FIRST CELL
OF AN ANIMAL LIFE --

THE FERTILIZED EGG.

MALE AND FEMALE ORGANISMS RESULT FROM THIS FERTILIZED EGG.

BUT A LIFE SPIRAL
ACTUALLY INTRODUCES

A NEW LEVEL OF ORGANIZATION
FOR US -- THE POPULATION.

POPULATIONS ARE ONE OR MORE ORGANISMS OF THE SAME TYPE,

LIVING AND INTERACTING TOGETHER.

SUCCESSFUL LIFE SPIRALS
MAINTAIN POPULATIONS.

WE WILL FOCUS ON POPULATIONS
IN LATER SESSIONS.

WELL, DOUG, WHERE DOES THIS LEAVE US WITH OUR ANALOGIES

SUCH AS THE PHOTOCOPY MACHINE?

WE DIDN'T REALLY
FIND AN ANALOGY THAT WORKED.

PERHAPS THERE AREN'T ANY
FOR THE COMPLEX PROCESS

OF REPRODUCTION
IN THE LIVING WORLD.

THE PROCESS OF REPRODUCTION REALLY DOES SEEM TO BE

VERY SPECIAL AND INTRIGUING.

ALTHOUGH IT IS VERY COMMON,

AND WE SEE EVIDENCE OF IT
ALL AROUND US,

THERE IS STILL MUCH
FOR SCIENTISTS TO UNDERSTAND

ABOUT HOW LIFE

REPRODUCES ITSELF.

I AM SURE WE WILL CONTINUE
TO HEAR OF NEW DISCOVERIES

IN THIS FIELD OF RESEARCH.

IN OUR NEXT SESSION TOGETHER,

WE WILL CONTINUE TO CONSIDER
HOW LIFE RENEWS ITSELF,

AS WE TAKE A LOOK
AT PLANT LIFE CYCLES.

THIS WILL GIVE US
AN OPPORTUNITY

TO COMPARE PLANTS
WITH ANIMALS,

TO SEE IF THEY REALLY ARE
AS DIFFERENT AS THEY SEEM.

THANKS FOR BEING WITH US.

WE LOOK FORWARD
TO SEEING YOU NEXT TIME.

GOODBYE.
BYE.

*FUNDING FOR THIS PROGRAM*
*IS PROVIDED BY ANNENBERG/CPB*

*TO ADVANCE EXCELLENT TEACHING.*

*FOR INFORMATION ABOUT THIS*

*AND OTHER*
*ANNENBERG/CPB PROGRAMS,*

*CALL 1-800-LEARNER*

*AND VISIT US AT*
*www.learner.org.*