FUNDING FOR THIS PROGRAM
IS PROVIDED BY ANNENBERG/CPB

TO ADVANCE EXCELLENT TEACHING.

OUR EARTH IS HOME

TO AN ASTONISHING DIVERSITY
OF LIFE.

FROM THE TENS OF THOUSANDS
OF SPECIES

IN A TROPICAL
RAINFOREST'S CANOPY

TO THE AMAZING
MICROBIAL DIVERSITY

FOUND IN A TEASPOONFUL
OF GARDEN SOIL,

LIFE THRIVES.

WITHIN THE DARKEST FATHOMS
OF THE OCEAN

LIE NEW FRONTIERS HARBORING

A PREVIOUSLY
UNTOLD STORY OF LIFE.

FROM OCEAN FLOOR TO TREETOP,

IN ADDITION TO THE LIFE FORMS
WE DO KNOW,

MANY THOUSANDS OF NEW SPECIES ARE DISCOVERED EVERY YEAR.

BUT WHAT DO WE CALL THEM?

WHERE DO THEY BELONG?

PRESENTED WITH LIFE'S PROFUSION,

WE SEEK WAYS TO ORDER OUR WORLD

AND FROM THIS ORDER

RECONSTRUCT THE STORY
OF HOW LIFE EVOLVED ON EARTH.

A STORY THAT BEGINS
WITH THE QUESTION --

HELLO, WELCOME BACK
TO ESSENTIAL SCIENCE.

I'M DOUGLAS ZOOK,
A BIOLOGIST

AND SCIENCE EDUCATOR
AT BOSTON UNIVERSITY.

AND I'M LINDA GRISHAM,
A BIOCHEMIST

AND SCIENCE EDUCATOR
AT LESLEY UNIVERSITY.

DOUG AND I WILL BE WITH YOU THROUGHOUT THIS COURSE,

WHICH FOCUSES
ON LIFE SCIENCE FOR TEACHERS

IN KINDERGARTEN
THROUGH SIXTH GRADE CLASSROOMS.

IN OUR LAST SESSION TOGETHER,
WE EXPLORED CHARACTERISTICS

THAT ARE SHARED
BY ALL LIFE FORMS.

THESE CHARACTERISTICS
REPRESENT UNIFYING THEMES

IN A REMARKABLY
DIVERSE LIVING WORLD.

Zook:
DURING TODAY'S SESSION,

WE'LL CONSIDER HOW THE
VAST DIVERSITY OF LIFE ON EARTH

STEMS FROM VARIATIONS
ON THESE SAME UNIFYING THEMES.

DIFFERENCES BETWEEN PLANTS
AND ANIMALS, FOR EXAMPLE,

ARE DIRECTLY LINKED
TO FUNDAMENTAL DIFFERENCES

BETWEEN THEIR CELLS.

Grisham:
WITH LIFE EXISTING IN ALMOST

EVERY CONCEIVABLE HABITAT

AND ON NEARLY
EVERY SURFACE ON EARTH,

HOW CAN WE MAKE SENSE
OF THE LIVING WORLD?

HOW CAN WE ANSWER THE QUESTION

"WHAT IS IT --
ANIMAL, VEGETABLE, OR OTHER?"

CHILDREN ARE
INTRINSICALLY INTERESTED

IN PLANTS AND ANIMALS.

MANY OF THEM
HAVE THEIR OWN PETS,

WHETHER THEY'RE FISH,
OR CATS OR DOGS.

THEY ALSO PROBABLY HAVE
GARDENED WITH THEIR PARENTS,

THERE'S ALSO ACCESS TO INSECTS

AND OTHER KINDS OF ORGANISMS
IN THAT ENVIRONMENT.

OH, THERE'S SOMETHING ELSE
IN THERE.

CAN WE OPEN IT?

YOU CAN OPEN IT.

Shuler: THEY CAN HAVE

VERY FOCUSED EXPLORATIONS

WITH THOSE ORGANISMS
THAT BEGIN TO BUILD

AN UNDERSTANDING
OF THE WAYS THAT THEY'RE ALIKE,

THE WAYS THAT THEY'RE DIFFERENT.

YEAH, YOU CAN TOUCH THEM.

Shuler:
AND THEN BECOME BETTER PREPARED

FOR UNDERSTANDING
OF MORE COMPLEX ISSUES

SUCH AS POPULATIONS, COMMUNITIES, ECOSYSTEMS,

AND EVENTUALLY
THE MUCH MORE THEORETICAL BASIS

OF BIOLOGY AND THAT IS UNDERSTANDING EVOLUTION.

YOU HAVE TO HAVE
AN UNDERSTANDING

OF HOW TO CLASSIFY ORGANISMS,

AND TO CLASSIFY THEM
YOU HAVE TO UNDERSTAND THE WAYS

THAT DIFFERENT SPECIES
ARE DIFFERENT.

OOH, MRS. SELZNICK,
SOMETHING BLACK.

Woman:
SOMETHING BLACK IS IN THERE?

OOH, A PILLBUG.

Boy:
WE HAVE THE SAME THING, TOO.

Woman:
I WONDER WHAT IT IS?

Shuler:
CLASSIFICATION IS IMPORTANT

IN ORDER TO BEGIN
TO BRING SOME RATIONALITY

AND ORDER TO DEFINING LIFE.

NOTICE ANYTHING DIFFERENT FROM YESTERDAY AND TODAY?

WE HAVE THE SAME THING.

SHULER HAS INTRODUCED THE TOPIC FOR THIS SESSION --

CLASSIFICATION.

HOW LIVING THINGS ARE GROUPED, BASED ON ESTABLISHED CRITERIA.

LIFE FORMS CAN BE CLASSIFIED
IN DIFFERENT WAYS,

DEPENDING ON
THE CLASSIFIER'S PURPOSE.

ON EARTH,
THERE ARE TWO MAJOR HABITATS --

AQUATIC AND TERRESTRIAL.

AQUATIC HABITATS
CAN BE FRESHWATER OR SALTWATER.

TERRESTRIAL HABITATS
INCLUDE DIFFERENT KINDS OF

WOODLANDS, DESERTS,

GRASSLANDS, AND OTHERS.

GROUPING ORGANISMS BY HABITAT

CAN REVEAL
NOT ONLY HOW DIVERSE LIFE IS,

BUT ALSO
THE INTIMATE CONNECTIONS

BETWEEN ORGANISMS
AND THEIR HABITATS.

TODAY WE'LL FOCUS ON A STRATEGY
SCIENTISTS USE

TO GROUP LIVING THINGS

THAT INVOLVES
A SYSTEMATIC APPROACH

TO BIOLOGICAL CLASSIFICATION

OF PLANTS, ANIMALS,
AND OTHER LIFE FORMS.

WE'LL START
WITH PLANTS AND ANIMALS

BECAUSE MANY ELEMENTARY
SCIENCE CURRICULA

INCLUDE UNITS
THAT FOCUS UPON THESE GROUPS.

CELLS ARE AN IMPORTANT CLUE
IN CLASSIFICATION.

LET'S LOOK BACK AT CELLS

AND SEE WHERE THEY FIT
INTO OUR LIVING WORLD.

YOU MAY RECALL
THAT THE CELL

IS CONSIDERED THE BUILDING BLOCK OF ALL LIFE.

THIS IS A WAY OF REPRESENTING
LEVELS OF ORGANIZATION.

THE LEVELS FORM A HIERARCHY,
WHERE EACH LEVEL IS BUILT FROM

AND INCLUDES
EACH LEVEL BELOW IT.

Zook: ALL LIFE FORMS
ARE MADE OF CELLS.

WHAT LEVELS ARE "BELOW" CELLS?

MANY CELLS CONTAIN PARTS
CALLED ORGANELLES.

ORGANELLES ARE LIKE
THE ORGANS OF A CELL --

THEY DO SPECIFIC JOBS.

THE NUCLEUS, WHICH CONTAINS HEREDITARY MATERIAL,

IS A TYPE OF ORGANELLE.

ORGANELLES
AND ALL OTHER CELL PARTS

ARE MADE FROM ORGANIC MOLECULES.

ORGANIC MOLECULES
ARE BUILT FROM ATOMS,

WITH CARBON
PROVIDING THE FRAMEWORK.

Grisham: LOOKING AT LEVELS OF ORGANIZATION INVOLVES SCALE --

HOW THINGS COMPARE IN SOME
MEASURABLE QUANTITY, LIKE SIZE.

MUCH OF THE LIVING WORLD, INCLUDING CELLS,

EXISTS AT A MICROSCOPIC SCALE --

TOO SMALL
FOR THE NAKED EYE TO SEE.

TODAY, WE'LL START
BY FOCUSING ON CELLS

AS A WAY
OF CLASSIFYING ORGANISMS.

AND HOW SMALL ARE CELLS?

LET'S TAKE A LOOK
AT THIS METER STICK.

IT'S DIVIDED INTO CENTIMETERS.

IN EACH CENTIMETER

ARE 10 MILLIMETERS.

AND IN ONE MILLIMETER

YOU COULD FIT ABOUT
100 HUMAN CELLS,

DEPENDING UPON THE CELL TYPE.

DURING THIS
AND FUTURE SESSIONS,

WE'LL CONSIDER SCALE,

AND SEE HOW THE MICROSCOPE IS ONE OF THE MOST IMPORTANT TOOLS

WE HAVE IN THE LIFE SCIENCES.

FOR A TUTORIAL ON SCALE,
PLEASE VISIT OUR WEB SITE.

LET'S RETURN TO OUR QUESTION --

WHAT IS IT --
ANIMAL, VEGETABLE, OR OTHER?

OSBORNE AND FREYBERG FOUND THAT

ELEMENTARY

AND MIDDLE SCHOOL STUDENTS

OFTEN HOLD A NARROW MEANING
FOR THE CONCEPT "PLANT."

THEY EXCLUDE SUBSETS
OF THE SET "PLANT,"

LIKE WEEDS,
VEGETABLES, AND SEEDS.

DO YOU THINK THIS APPLIES
TO YOUR STUDENTS?

THE "SCIENCE STUDIO"
IS A PLACE

WHERE WE TRY
TO UNCOVER CHILDREN'S IDEAS

AS THEY ENGAGE
IN CAREFULLY DESIGNED ACTIVITIES

ADAPTED FROM
THE CURRICULUM RESOURCES

BEING FEATURED
IN EACH PROGRAM.

TODAY THE CHILDREN
WILL BE LOOKING AT PLANTS

FROM FRESHWATER
AND WOODLAND HABITATS

AND THINKING ABOUT HOW
THEY ARE ALIKE AND DIFFERENT.

WHAT WE ARE INTERESTED IN

ARE HOW THE CHILDREN
DEFINE A PLANT.

HOW ARE ALL PLANTS ALIKE?

OKAY, SO WHAT WE'RE GOING TO DO

IS WE'RE GOING TO WORK
ON THESE VENN DIAGRAMS.

AND SO YOU'LL HAVE
TWO FRESHWATER THINGS

AND TWO WOODLAND THINGS.

AND WHAT YOU'RE GOING TO DO
IS YOU'RE GOING TO DO

LIKE WE DID
IN THAT FIRST ACTIVITY.

YOU'RE GOING TO PUT THE THINGS THAT ARE DIFFERENT

FROM THE WOODLAND HERE,

AND THE THINGS THAT
ARE DIFFERENT

FROM THE FRESHWATER HERE,

AND THEN THE THINGS THAT
ARE SIMILAR GO IN THE MIDDLE.

WHAT DO THEY BOTH NEED?

I MEAN,

WHAT DO THEY BOTH HAVE?

THEY ALL HAVE STEMS,
EXCEPT THIS ONE.

YEAH,
SO YOU CAN'T REALLY SAY THAT.

THEY BOTH HAVE
SOME KIND OF GREEN,

OR SOME KIND OF LEAVES
OR SOME KIND OF THAT.

WELL, THEY'RE ALL GREEN.

WELL, BUT NOT
ALL SEA PLANTS ARE GREEN.

I KNOW.

I MEAN, NOT ALL
FRESHWATER PLANTS ARE GREEN.

WELL, THEY ALL HAVE
SOMETHING GROWING OFF THEM.

THIS HAS THIS,
THIS HAS THIS...

IT'S YOUR TURN TO WRITE.

THEY ALL HAVE SOMETHING
GROWING OFF OF THEM.

GRASSY OR GREEN THING
GROWING ON THEM.

Woman:
BUT THEY DON'T HAVE LEAVES?

THIS ONE DOESN'T HAVE LEAVES
AND THIS ONE DOESN'T,

BUT THESE ONES DO.

NO, THIS ONE
DOESN'T HAVE LEAVES.

OH, YEAH.

BUT THEY ALL HAVE SOME
SORT OF GREEN THING GROWING OFF.

LIKE, THEY ALL HAVE
SOME SORT OF LEAVES.

SOME SORT OF LIKE GRASS.

Woman: WELL, YOU'RE SAYING THAT SOME DON'T HAVE LEAVES, SOME DO.

DO ALL PLANTS
HAVE LEAVES OR NOT?

NO.

TREES DO, BUT THESE DON'T.

THESE DO.

Woman: TELL ME WHAT YOU THINK
A LEAF IS.

A GREEN THING
THAT GROWS ON A TREE.

Woman:
THEY BOTH NEED DIFFERENT THINGS?

DO THEY NEED
SOME OF THE SAME THINGS?

YEAH,
THEY BOTH NEED WATER.

AND THEY NEED THE SUN.

THE SUN,

TO KEEP THEM WARM.

Woman:
YOU WANT TO WRITE THAT DOWN?

Man: BUT, I MEAN,
DO THEY MOVE ON THEIR OWN?

THEY MIGHT,
I THINK THEY BOTH MOVE.

NO.

THEY DO NOT MOVE.

HOW CAN THEY MOVE BY THEMSELF?

THEY MOVE
'CAUSE THEY HAVE WISDOM.

WISDOM.

PLANTS DO HAVE WISDOM,

THEY DON'T HAVE BRAINS
BUT THEY HAVE WISDOM.

BUT THEY CAN'T MOVE
BY THEMSELVES.

SO I THINK THESE
YOU SHOULD PUT

"MOVE."

AND THESE "DON'T."

SO WHAT HAVE YOU NOTICED
THAT'S THE SAME?

THEY COULD BOTH
GROW TALL.

WHICH ONES?

WELL, BOTH OF THEM,

BOTH COULD PROBABLY
GROW TALL.

LIKE, IF THESE WEREN'T
PICKED OUT OF THE WATER.

IT COULD GROW TALL.

AND THIS COULD STILL
PROBABLY GROW TALL.

WHAT ABOUT THIS ONE?

THIS WOULD.

SO SOME COULD GROW TALL.

SO, DO YOU NOTICE
ANYTHING ELSE THAT'S SIMILAR?

THEY'RE BOTH PLANTS.

ALL OF THEM ARE PLANTS?

WHY DON'T YOU PUT
THAT DOWN THERE?

NOW WHAT DO YOU MEAN
BY THEY'RE ALL PLANTS?

ALL THESE
THAT WE HAD RIGHT HERE.

THEY NEED
SUN AND WATER TO GROW.

SUN, WATER,
AND SOIL OR DIRT OR SAND.

DO THEY ALL NEED THAT?
YES.

SO MAYBE THAT'S SOMETHING ELSE THAT COULD GO IN THE MIDDLE.

WATER.
SUN.

BUT THIS ONE NEEDS WATER.

OH, BOTH NEED SUN.

"BOTH NEED SUN."

THAT'S FUNNY
THE WAY YOU SAID IT.

LIKE "NEEEED SUUUUN."

Zook: IN DESCRIBING WAYS
THAT ALL PLANTS ARE ALIKE,

THE CHILDREN SEEMED TO AGREE ABOUT THESE FEATURES --

THEY'RE GREEN, THEY NEED SUN,

THEY NEED WATER,
THEY HAVE LEAVES,

THEY NEED AIR,
AND THEY NEED SOIL.

Grisham:
THESE ARE COMMON OBSERVATIONS,

BUT WHAT DO YOU THINK?

DO THEY DESCRIBE ALL PLANTS?

ARE THESE PLANTS GREEN?

WHAT ABOUT PLANTS
THAT LIVE IN DEEP SHADE

OR WHERE WATER
IS ALL BUT ABSENT?

DO YOU SEE ANY LEAVES
ON THESE PLANTS?

WHAT ABOUT SOIL?

SOMETHING THAT

OFTEN SURPRISES PEOPLE

IS THAT PLANTS
DO NOT NECESSARILY REQUIRE SOIL.

THIS IS A HYDROPONICALLY
GROWN PLANT,

THE SAME TYPE AS THIS ONE.

IT'S BEEN GROWN IN WATER

TO WHICH NUTRIENTS
HAVE BEEN ADDED.

THERE ARE MANY AQUATIC PLANTS THAT GROW LIKE THIS NATURALLY.

THE CHARACTERISTICS OF PLANTS DISCUSSED BY THE CHILDREN

ARE BASED ON EVERYDAY EXPERIENCE WITH PLANTS --

THAT'S THEIR STARTING POINT.

ARE THESE CHARACTERISTICS
THE SAME AS THOSE USED

IN THE BIOLOGICAL CLASSIFICATION OF PLANTS?

THERE ARE OVER 250,000 DIFFERENT TYPES OF PLANTS ON EARTH.

FROM TINY AQUATIC PLANTS,
CALLED DUCKWEED,

TO GIANT REDWOODS TALLER
THAN A 27-STORY BUILDING.

WE CAN SEE
HOW PLANTS ARE DIFFERENT,

BUT HOW ARE THEY ALL RELATED?

A STRATEGY USED
IN BIOLOGICAL CLASSIFICATION

INVOLVES LOOKING AT
CELL PROPERTIES.

LET'S TAKE A CLOSER LOOK
AT THE LEAVES OF THIS TREE

TO SEE HOW WE CAN CLASSIFY IT
IN THE LIVING WORLD.

WE NEED TO USE A MICROSCOPE

TO ANSWER FOUR QUESTIONS
ABOUT ITS CELLS.

PLANTS ARE MULTICELLULAR.

A SINGLE TREE IS MADE UP
OF TRILLIONS OF CELLS.

A CLOSER EXAMINATION
OF A SINGLE CELL

REVEALS THE PRESENCE
OF A NUCLEUS.

THE PRESENCE OR ABSENCE
OF A NUCLEUS

IS ONE OF THE MOST BASIC DISTINCTIONS

IN BIOLOGICAL CLASSIFICATION.

TAKE A LOOK AT THE BOUNDARY
AROUND EACH CELL,

THE PRESENCE OF THIS BOUNDARY

GIVES US THE ANSWER
TO OUR NEXT QUESTION.

THIS BOUNDARY IS THE CELL WALL.

IT'S A THICKENED STRUCTURE SURROUNDING EACH CELL.

THE CELL WALL
IS MADE OF A TOUGH SUBSTANCE

THAT PROVIDES RIGIDITY
TO ALL PLANT CELLS.

OUR FINAL QUESTION IS --

THE ABILITY TO MAKE FOOD

IS AN IMPORTANT FEATURE
USED IN PLANT CLASSIFICATION.

DURING PHOTOSYNTHESIS,

PLANT CELLS USE ENERGY
FROM SUNLIGHT,

CARBON DIOXIDE FROM THE AIR,

AND WATER
TO MAKE THEIR OWN FOOD.

THIS FOOD IS USED BY THE PLANT

FOR BUILDING MATERIALS
AND ENERGY.

THE ANSWERS
TO OUR FOUR QUESTIONS

CAN BE USED TO CLASSIFY
THE TREE AS A PLANT.

Zook:
WHEN OVER 2,000

KINDERGARTEN THROUGH
EIGHTH GRADE STUDENTS

WERE ASKED
WHAT DEFINES AN ANIMAL,

THE MOST COMMON RESPONSES INCLUDED --

HOW DO THESE RESPONSES

COMPARE WITH YOUR DEFINITION
OF AN ANIMAL?

TO FIND OUT HOW CHILDREN THINK
ALL ANIMALS ARE ALIKE,

WE GAVE THEM FOUR EXAMPLES --

A FISH AND A SNAIL
FROM A FRESHWATER HABITAT,

AND A BEETLE AND A PILL BUG
FROM A WOODLAND HABITAT.

THANK YOU.

NOW, WHAT'S AN ANIMAL?

AN ANIMAL'S SOMETHING THAT
NEEDS FOOD,

SHELTER, WATER.

WAIT, OUR SCIENCE TEACHER
TAUGHT US THIS.

SHE SAID,
SHELTER, FOOD, AND WATER.

DID YOU PLAY A GAME?

NO.

WELL, WE DID, UM,

FOOD, SHELTER, WATER.

DO YOU KNOW HOW SNAILS
GET THEIR AIR?

Woman: THAT'S A GOOD QUESTION,
DO THEY NEED AIR?

NO.
YES.

THEY DON'T NEED AIR.

HOW CAN ANYTHING LIVE
WITHOUT AIR?

IT COULD.

Woman:
WHY DO YOU THINK THAT?

I MEAN, YOU SAID
THAT ALL ANIMALS NEED OXYGEN.

NEED SUN AND WATER

AND THEY NEED FOOD.

THEY CAN HAVE SUN AND WATER,

BUT I DON'T THINK
THEY REALLY, REALLY NEED --

BUT THE SUN'S,
LIKE, FEEDING THEM.

THEY, LIKE, EAT

BECAUSE WHEN YOU WATER THEM,

LIKE, WITH THEIR --

THEY HAVE WISDOM,
THEY DON'T.

THEY HAVE WHAT?

WELL, THESE ONES
DON'T REALLY THINK.

THESE DO.

THEN PUT THAT DOWN FIRST.

THEY HAVE BRAINS.

WELL, I DON'T THINK PLANTS
HAVE BRAINS, THEY HAS WISDOM --

THESE HAVE BRAINS
AND THESE DON'T.

YEAH, THESE DON'T EVEN THINK, BUT THEY DO HAVE WISDOM.

PLANTS DO HAVE WISDOM.

WELL,
WHY DON'T YOU PUT DOWN --

BRAINS.

AND THEN I'LL WRITE.

NO BRAINS.

NO.

NOT SMART.

AND THEN I'LL JUST WRITE --

THEY HAVE NO BRAIN.

WHERE CAN THEY FIT THE BRAIN,
IN THE LEAF THAT FALLS OFF?

NO, THEY'LL LOSE THEIR BRAIN.

Girl: OH, A BEETLE.

BEETLE AND SOMETHING ELSE.

I STILL HAVEN'T TOUCHED HIM.

I KNOW, THEY CAN MOVE
BY THEMSELVES.

CAN THEY?

LOOK AT THE FISH
AND LOOK AT THEM,

AND LOOK AT THE BEETLE,
LOOK AT THE BEETLE.

BUT THOSE CAN'T MOVE.

NO, WE HAVE TO MOVE THEM, SEE.

CAN MOVE.

Grisham:
THERE WERE SEVERAL FEATURES

THAT THE CHILDREN
SEEMED TO AGREE UPON

WHEN DECIDING
HOW ALL ANIMALS ARE ALIKE.

Zook:
THESE IDEAS MAKE SENSE,

BECAUSE OF THE EXAMPLES
THAT THEY ENCOUNTER EVERYDAY --

FAMILIAR ANIMALS LIKE HAMSTERS, DOGS, BIRDS, OR FISH.

Grisham:
MOST ANIMALS DON'T HAVE

WHAT WE WOULD RECOGNIZE
AS A BRAIN.

THIS JELLYFISH
IS A GOOD EXAMPLE.

ANOTHER CHARACTERISTIC
THAT IS FREQUENTLY

ASSOCIATED WITH ANIMALS
IS MOVEMENT.

IT CAN BE SEEN THAT
SOME ANIMALS CANNOT MOVE,

AT LEAST NOT DURING
ALL PHASES OF THEIR LIFE SPANS.

AND WHAT ABOUT A BRYOZOAN,

AN AQUATIC ANIMAL
THAT LOOKS LIKE A PLANT?

DO ALL OF THESE CHARACTERISTICS

APPLY TO THIS
UNFAMILIAR EXAMPLE?

AND WHAT ABOUT
ALL THE OTHER ANIMALS?

WHAT CHARACTERISTICS
MIGHT SCIENTISTS USE

TO CLASSIFY AN ANIMAL?

GIGANTIC AND MINUTE,

LEATHERY AND SLEEK,

FURRY AND SCALY,

RIGID AND FLEXIBLE,

HOOFED, FLIPPERED, AND WINGED.

TAME AND FIERCE.

THE WORDS
THAT DESCRIBE THESE ANIMALS

ARE AS VARIED
AS THE ANIMALS THEMSELVES.

WHAT FEATURES SUGGEST THAT ALL
OF THESE ORGANISMS ARE RELATED?

LET'S TAKE A CLOSER LOOK
AT A FAMILIAR ANIMAL, A FROG.

WHILE VIEWING ITS SKIN CELLS
UNDER A MICROSCOPE

WE CAN ONCE AGAIN ASK
FOUR QUESTIONS ABOUT THE CELLS

TO PROVIDE INFORMATION USED
TO CLASSIFY THE FROG.

ARE THERE MANY CELLS?

WE CAN OBSERVE THAT THE FROG
IS MADE OF MANY CELLS.

DO THE FROG CELLS
CONTAIN A NUCLEUS?

FROG CELLS DO CONTAIN A NUCLEUS.

NOTICE THE CELL BOUNDARIES.

IS THERE A CELL WALL?

THE OUTERMOST
BOUNDARY OF THESE CELLS

IS THE CELL MEMBRANE.

UNLIKE PLANTS,
ANIMAL CELLS ARE NOT SURROUNDED

BY A THICKENED CELL WALL.

ANIMALS ARE ALSO CLASSIFIED

ACCORDING TO
HOW THEY OBTAIN FOOD.

ANIMAL CELLS
DO NOT MAKE A FOOD SUPPLY.

THEY MUST TAKE IN
"READY-MADE" FOOD

THAT ALREADY EXISTS

IN THE BODIES
OF OTHER LIFE FORMS.

ANIMALS TAKE IN FOOD
THROUGH INGESTION --

THEY EAT IT WHOLE

OR IN MANAGEABLE CHUNKS.

ONCE INSIDE THE ANIMAL,
FOOD IS DIGESTED.

FOOD MOLECULES
ARE THEN TRANSPORTED

TO THE ANIMAL'S CELLS

WHERE THEY BECOME
SOURCES OF MATTER AND ENERGY.

THE ANSWERS
TO OUR FOUR QUESTIONS

CAN BE USED TO CLASSIFY THE FROG AS AN ANIMAL.

LET'S RETURN
TO THE SCIENCE STUDIO.

WHEN COMPARING
PLANTS AND ANIMALS,

THE CHILDREN DISCUSSED IDEAS
THAT REQUIRE A CLOSER LOOK

AT BOTH OF THESE
FAMILIAR GROUPS.

WELL, THEY'RE THE SAME
'CAUSE THEY BOTH NEED GAS.

THEY BOTH NEED GAS.

YEAH, GAS.

DO YOU AGREE WITH THAT,
FIACHRA?

LIKE WHAT KIND OF GAS?

I DON'T MEAN LIKE
THE SMELLY GAS.

IN A CAR TANK
OR ANYTHING LIKE THAT.

I MEAN LIKE THE GAS THAT MAYBE COMES OUT OF THE CARS.

LIKE GASES IN HERE.

GAS.

ANIMALS NEED GAS.

GAS IS IN AIR,
THAT'S TRUE.

SO, DO ALL OF THEM NEED AIR?

THERE'S THREE MAIN THINGS.

AIR, OXYGEN.

RIGHT NOW
YOU'RE BREATHING IN GAS.

IT'S HARD TO BELIEVE IT,
YOU REALLY ARE.

A-I-R-.

AND, OF COURSE.

GAS.

AND, OF COURSE, OXYGEN.

THOSE ARE HOLES FOR AIR.

I THINK IT WAS MADE FOR A DIFFERENT ANIMAL THAN FISH.

LIKE, LAST TIME
WE HAD MICE IN HERE.

BECAUSE THESE HAVE GILLS SO THAT THEY CAN BREATH IN THE WATER.

WHEN THE WATER GOES INTO THEM
IN THEIR GILLS, IT TURNS INTO --

SOMEHOW IT TURNS INTO AIR,
WHICH IS WHAT THEY BREATHE.

I'M NOT SURE IF THAT'S TRUE.

I THINK THEY TAKE OUT
ALL THE AIR FROM THE WATER --

IS THERE ANY AIR IN WATER?

WELL, H2O,

HYDROGEN PLUS OXYGEN.

SO THEY TAKE THE OXYGEN OUT --

YEAH, YOU'RE RIGHT.

SO, I THINK
THAT'S HOW FISH BREATHE

AND THEN REGULAR ANIMALS
BREATHE

BECAUSE THE TREES
TAKE IN THE BAD --

THE CARBON DIOXIDE.

THE CARBON DIOXIDE
AND MAKE IT INTO OXYGEN,

SO WE CAN BREATHE THERE.

WHO DOES THAT?
I MISSED THAT.

THE TREES.

THE TREES TAKE IN --

THE CARBON DIOXIDE.

'CAUSE THAT'S WHAT
THEY BREATHE,

AND THEY LET OUT THE OXYGEN
THAT WE BREATHE.

AND ACTUALLY
ALL PLANTS DO THAT.

I THINK WHAT HAPPENS IS
THEY BREATHE IN ALL THE WATER,

THEY PUT IT IN A STORAGE PLACE

AND THEY PUT THE HYDROGEN

IN SOME SORT OF PLACE
IN THEIR BODY WHERE

IT KEEPS IT FOR JUST LIKE
SOME SORT OF THING.

THE HYDROGEN GOES
SOMEWHERE IN THEIR BODY,

AND THEY TAKE THE OXYGEN,

AND IT GOES INTO THEIR BODY
WHERE THEY NEED IT,

AND THEN THE OXYGEN IS
THE ONE THING THAT ANIMALS NEED

AND CO2 IS THE ONE THING
THAT PLANTS NEED.

LEO AND SOME OF
THE OTHER CHILDREN

HAVE VERY FIRM BELIEFS ABOUT
THE NEEDS OF PLANTS AND ANIMALS

FOR SPECIFIC
COMPONENTS OF AIR --

EITHER CARBON DIOXIDE OR OXYGEN.

IS LEO RIGHT?

WHICH GASES ARE REQUIRED
BY PLANTS OR ANIMALS?

Grisham: LIFE REQUIRES
A CONSTANT SUPPLY

OF NEW MATTER AND ENERGY
FOR THE LIFE PROCESSES

THAT OCCUR

EVERY MINUTE OF EVERY DAY.

ORGANIC MOLECULES
ARE THE MATTER OF LIFE.

EACH LIVING THING MUST BUILD
IT'S OWN ORGANIC MOLECULES

WITH CARBON BEING
THE FUNDAMENTAL BUILDING BLOCK.

WHERE DO PLANTS AND ANIMALS
GET THE CARBON

AND THE OTHER MATERIALS THEY
NEED TO BUILD ORGANIC MOLECULES?

PLANTS EXTRACT CARBON DIOXIDE
FROM THE AIR

AND WATER FROM THE SOIL,

ALONG WITH THE NUTRIENTS
THAT THIS WATER CARRIES.

DURING PHOTOSYNTHESIS
AND SUBSEQUENT CELL PROCESSES,

THESE RAW INGREDIENTS
ARE COMBINED IN NEW WAYS

TO FORM ORGANIC MOLECULES
THAT MAKE UP A PLANT.

THE CARBON
THAT IS USED TO BUILD A PLANT

IS SUPPLIED ENTIRELY
BY CARBON DIOXIDE FROM THE AIR.

WHERE DO ANIMALS GET THE CARBON
AND OTHER MATERIALS THEY NEED?

ANIMALS INGEST FOOD
FROM LIVING SOURCES

THAT PROVIDE A SUPPLY OF "READY-MADE" ORGANIC MOLECULES

THAT ALREADY CONTAIN CARBON.

ORGANIC MOLECULES
CONTAINED IN FOOD ARE DIGESTED

AND REARRANGED TO FORM THE MATTER THAT COMPOSES THE ANIMAL.

WHAT ABOUT OXYGEN?

A CANDLE REQUIRES OXYGEN TO BURN

AND RELEASE THE ENERGY
STORED IN WAX.

IN A SIMILAR PROCESS,

ANIMALS USE OXYGEN
TO BURN FOOD FOR ENERGY.

MOST PEOPLE
ARE SURPRISED TO FIND OUT

THAT PLANTS ALSO USE OXYGEN
IN THE SAME WAY --

TO RELEASE ENERGY IN THEIR FOOD.

THE IDEA THAT PLANTS REQUIRE BOTH CARBON DIOXIDE AND OXYGEN

MAY BE SURPRISING AT FIRST.

BUT WHEN YOU THINK OF OXYGEN

AS BEING REQUIRED
TO BURN FOOD FOR ENERGY,

AND REALIZE THAT BOTH PLANTS
AND ANIMALS

MUST GET ENERGY FROM FOOD,
IT MAKES SENSE.

ANOTHER IMPORTANT IDEA

IS THAT ALL OF THIS
TAKES PLACE INSIDE CELLS.

BREATHING AND EATING
ARE REALLY JUST PROCESSES

THAT SERVE THE PURPOSE

OF BRINGING
THE RIGHT MATTER TO THE CELLS.

WHAT ABOUT AQUATIC PLANTS
AND ANIMALS?

GASES ARE FOUND
IN BOTH AIR AND WATER,

AND THE MOVE UNCHANGED
BETWEEN THEM.

IN WATER, GASES ARE DISSOLVED,

BUT THEIR COMPOSITION
IS THE SAME AS IT IS THE AIR.

WATER OR CARBON DIOXIDE
AREN'T SPLIT APART

TO PROVIDE OXYGEN
FOR AQUATIC ANIMALS,

LIKE SOME OF
THE CHILDREN REASONED.

IT'S TIME TO SEE
WHAT'S HAPPENING

WITH OUR ON-GOING WEB ACTIVITY, BOTTLE BIOLOGY.

IT'S NOT TOO LATE
TO GET YOUR OWN SYSTEM STARTED,

IF YOU HAVEN'T ALREADY.

HI, I'M PAUL WILLIAMS.

TIME TO TAKE A PEEK
AT THE BOTTLE BIOLOGY SYSTEMS

WE'VE SET UP.

HOPE YOURS IS UP AND RUNNING.

IN THE BRASSICA
AND BUTTERFLY SYSTEM,

THESE TINY BUTTERFLY EGGS
SHOULD SOON BE HATCHING.

WE'LL TAKE A CLOSER LOOK

AT THE LIFE CYCLES

OF BOTH THE BUTTERFLIES
AND THE BRASSICA

AS THE SYSTEM DEVELOPS.

SPROUTS ARE APPEARING NOW
IN THE FIELD POPULATION SYSTEM.

NOTICE HOW SIMILAR
ALL THE SPROUTS APPEAR NOW.

YOU'LL BE SURPRISED
AT WHAT HAPPENS

WHEN THEY CONTINUE TO GROW.

THE ECOCOLUMN SYSTEM

IS BEGINNING
TO BUSTLE WITH ACTIVITY.

SEE HOW THE ANIMALS ARE FINDING PLACES TO BUILD THEIR HOMES?

WE'LL HAVE TO KEEP TRACK
OF CHANGES IN THIS SYSTEM

AND WATCH
THE ORGANISMS INTERACT.

LET'S FOCUS ON
THE TERRAQUA SYSTEM TODAY.

THIS SYSTEM FEATURES THE
TWO MAJOR HABITATS ON EARTH --

TERRESTRIAL AND AQUATIC.

THIS IS A GREAT SYSTEM
FOR OBSERVING

THE CHARACTERISTICS OF LIFE,

AND FOR COMPARING DIFFERENT TYPES OF LIVING THINGS.

LET'S TAKE A LOOK AT SOME
OF THE MICROBES IN THE WATER.

THERE'S A LOT OF DIVERSITY
IN THE AQUATIC HABITAT

THAT ISN'T OBVIOUS AT FIRST.

THIS INVISIBLE WORLD CAN BE BROUGHT INTO THE CLASSROOM

WITH JUST A SIMPLE MICROSCOPE.

VISIT BOTTLE BIOLOGY
ON OUR WEBSITE.

THERE YOU CAN FIND ACTIVITIES

THAT YOU CAN DO
WITH YOUR OWN SYSTEM,

AND YOU CAN CHECK OUT
THE PROGRESS WITH OURS.

OBSERVING PLANTS AND ANIMALS IN
AQUATIC AND TERRESTRIAL HABITATS

IS THE FOCUS
OF TODAY'S FEATURED CLASSROOM.

STEPHANIE SELZNICK,

A SCIENCE SPECIALIST,

IS USING THE STC ORGANISMS UNIT
WITH FIRST GRADERS

AT THE HOLMES SCHOOL
IN BOSTON, MASSACHUSETTS.

I'M GOING TO PASS OUT
YOUR TERRARIUMS.

JASON'S GROUP,
JUST PUSH THAT RIGHT DOWN.

YOU CAN OPEN IT.

Boy: I SEE A POOPIE.

YOU SEE A POOPIE?

Boy: WHAT IS THAT?

IT'S A POOPIE.

Boy: IT FELL IN THE FLOOR.

Selznick: THAT'S OKAY.

THE MILLIPEDE FELL ON THE FLOOR.

IS HE OKAY?

YEAH, HE'S OKAY.

Shuler:
THE BIG IDEAS THAT ARE CONTAINED

IN THE STC ORGANISMS UNIT FOR
KINDERGARTEN AND FIRST GRADERS,

WHICH IS THE FIRST UNIT
IN THE LIFE CYCLE STRAND,

INCLUDE THE PRINCIPLES
OF DIVERSITY OF LIFE

AND ALSO THE FOUNDATIONS FOR
THE CLASSIFICATION OF ORGANISMS.

WHO CAN TELL ME WHAT THEY OBSERVED IN THEIR TERRARIUM?

Boy:
HE WAS MAKING A HOLE.

WHO WAS MAKING A HOLE?

THE MILLIPEDE.

THE MILLIPEDE MADE A HOLE,
ALL RIGHT.

AND NOW I'M GOING TO HAND OUT THE AQUARIUMS.

Class: YEAH!

ALL RIGHT, ARE YOU LOOKING THROUGH YOUR MAGNIFYING GLASSES?

WHAT KIND OF ANIMALS
DO WE HAVE IN OUR AQUARIUM?

Boy: FISH.

WHAT KIND OF FISH?

DOES ANYBODY KNOW
THE NAME OF THOSE FISH?

Boy: GUPPIES.

GUPPIES.

Selznick:
WHEN WE DO OUR ACTIVITY,

"HOW ARE PLANTS
ALIKE AND DIFFERENT"

AND "HOW ARE ANIMALS
ALIKE AND DIFFERENT,"

I PUT THE CHART UP ON THE BOARD AND I GIVE THEM THE QUESTION

AND WE GO OVER
HOW ARE THEY ALIKE,

WHAT DO THEY ALL NEED?

WHAT DO PLANTS NEED?

WATER.

COME ON UP.

ALL RIGHT.

WHAT ELSE IS A NEED, CHRIS?

SOIL.

WHO DID NOT GET A TURN YET, NEAL?

THE SUN.

THE SUN.

ANYTHING ELSE?

ERQUANA?

FOOD, FOOD.

YEAH, IT NEEDS FOOD.

WE KNOW A LOT ABOUT ANIMALS
FROM BEING IN THIS CLASSROOM,

SO WHAT ARE SOME OF THE NEEDS
OF ANIMALS?

ALL RIGHT, TYREQUE?

FOOD.

Shuler: USING A STRATEGY
SUCH AS THE VENN DIAGRAM,

THAT REALLY HELPS THEM FOCUS THROUGH THEIR STUDIES

AND IDENTIFY THOSE
COMMON CHARACTERISTICS

AROUND LIVING THINGS.

IT BEGINS TO CHALLENGE
THEIR PRE-CONCEIVED IDEAS

AND HELPS THEM TO DEVELOP
A NEW FRAMEWORK

AS THEY BEGIN THEIR FURTHER
EXPLORATIONS IN THIS AREA.

Selznick: I NOTICED WHEN
WE WERE DOING THE LESSON TODAY

THAT WHEN WE WERE DOING

THE PLANTS AND THE ANIMALS
AND THE NEEDS,

I NOTICED THAT
THEY PUT A LOT OF EMPHASIS

ON WHAT HUMANS WANT,

WHAT THEIR ATTRIBUTES ARE.

UM, FEET.

EYES.

EYES, COME ON UP.

JAQUARIA.
LEGS.

OF COURSE THEY'VE GOT LEGS.

WELL, CAN WE LEAVE FEET
AND LEGS BEING THE SAME?

NO.

'CAUSE LEGS WALK
AND FEET WIGGLE.

ALL RIGHT, ALL RIGHT.

A PILLBUG AGAIN.

Selznick: THEY LOVE
LOOKING AT LIVING THINGS.

I MEAN, FIRST GRADE,

ANY GRADE, PUT ANY LIVING THING IN FRONT OF THEM

AND THEY'RE ALL "WOO,"
YOU KNOW?

YOU CAN SEE IT ON THEIR FACES, THE EXCITEMENT.

OBSERVING ORGANISMS
IN THEIR HABITATS --

EVEN THOSE THAT ARE
CUSTOM-MADE FOR A CLASSROOM --

IS A GOOD WAY
TO GET YOUNG CHILDREN

TO BEGIN TO DISTINGUISH
BETWEEN PLANTS AND ANIMALS.

AS CHILDREN GAIN EXPERIENCE,
HOWEVER,

THEY ARE LIKELY
TO BECOME AWARE

OF LIFE FORMS
THAT DON'T QUITE FIT

THEIR DEFINITIONS
OF PLANTS OR ANIMALS.

SCIENTISTS HAVE CLASSIFIED

OVER 1.5 MILLION
DIFFERENT TYPES OF ORGANISMS.

CURRENTLY, UP TO 10,000
NEW SPECIES ARE NAMED EACH YEAR.

MANY OF THESE AREN'T CLASSIFIED AS PLANTS OR ANIMALS.

WHAT ARE THE OTHERS
THAT LIVE AMONG US?

IN EARLY CLASSIFICATION SCHEMES,

MUSHROOMS WERE GROUPED
WITH PLANTS,

BECAUSE OF SIMILARITIES
IN APPEARANCE AND GROWTH HABITS.

MUSHROOMS ARE ACTUALLY MEMBERS

OF A GROUP OF ORGANISMS
CALLED FUNGI.

FUNGI INCLUDE TOADSTOOLS,
MOLDS, AND YEASTS.

LIKE PLANTS,
MULTICELLULAR ORGANIZATION

IS USED TO CLASSIFY
SOMETHING AS A FUNGUS,

ALTHOUGH A FEW TYPES
ARE UNICELLULAR.

FUNGI ALSO HAVE CELLS THAT
CONTAIN ONE, OR MORE, NUCLEI.

PRESENCE OF A CELL WALL
IS ALSO USED TO CLASSIFY FUNGI.

HOWEVER, THE CELL WALLS OF FUNGI ARE MADE OF A SUBSTANCE

THAT IS VERY DIFFERENT
FROM THE CELL WALLS OF PLANTS.

THE MOST DISTINCTIVE FEATURE
USED TO CLASSIFY FUNGI

INTO A DIFFERENT GROUP
FROM PLANTS,

IS HOW THEY OBTAIN FOOD.

FUNGI CANNOT
MAKE THEIR OWN FOOD.

FUNGI SECRETE
DIGESTIVE CHEMICALS

INTO THEIR EXTERNAL ENVIRONMENT

AND BREAK DOWN FOOD
INTO FOOD MOLECULES.

ABSORPTION ACROSS CELL WALLS

BRINGS FOOD MOLECULES
INTO THEIR CELLS.

LIKE ANIMALS,
FUNGI MUST TAKE FOOD IN.

THEY DIFFER FROM ANIMALS
IN THIS REGARD

BECAUSE THEY ABSORB FOOD
RATHER THAN INGEST IT.

THE DISTINCTIVE NATURE OF FUNGI

JUSTIFIES
A SEPARATE CLASSIFICATION

FROM EITHER PLANTS OR ANIMALS.

UP TO 1,000 NEW SPECIES OF FUNGI
ARE DESCRIBED EACH YEAR.

A FOURTH GROUP IS A CATCH-ALL
GROUP CALLED THE PROTISTS.

THE PROTISTS ARE ORGANISMS
THAT HAVE A NUCLEUS

BUT AREN'T OTHERWISE CLASSIFIED AS PLANTS, ANIMALS, OR FUNGI.

PROTISTS INHABIT
A LARGELY MICROSCOPIC WORLD

AND ARE ABUNDANT IN AQUATIC
AND TERRESTRIAL HABITATS.

MOST ARE
SINGLE-CELLED ORGANISMS,

WITH A FEW NOTABLE EXCEPTIONS --

THE ALGAE.

PROTISTS INCLUDE PLANT,
ANIMAL, AND FUNGUS-LIKE FORMS.

PLANT AND FUNGUS-LIKE FORMS
HAVE CELL WALLS.

ANIMAL-LIKE FORMS DO NOT.

PLANT-LIKE FORMS
MAKE THEIR OWN FOOD,

FUNGUS-LIKE FORMS
ABSORB FOOD,

AND ANIMAL-LIKE FORMS
INGEST FOOD.

THIS MAKES PROTISTS
AN EXTREMELY DIVERSE GROUP

THAT DOESN'T EASILY CONFORM

TO SIMPLE
CLASSIFICATION STRATEGIES.

SO FAR
WE HAVE IDENTIFIED ORGANISMS

THAT ARE CLASSIFIED
INTO FOUR DIFFERENT GROUPS --

SCIENTISTS CURRENTLY CALL
EACH OF THESE GROUPS A KINGDOM.

THE MEMBERS
OF THESE FOUR KINGDOMS

ARE GROUPED TOGETHER
INTO A LARGER GROUP

UNITED BY ONE FEATURE --

CELLS THAT HAVE A NUCLEUS.

THIS LARGER GROUP
IS CALLED A DOMAIN.

THIS DOMAIN
IS CALLED THE EUKARYA.

THE CHILDREN
IN THE SCIENCE STUDIO

REVEAL SOME OF THEIR THOUGHTS ABOUT THESE OTHER ORGANISMS.

I'M GOING
TO SHOW YOU SOME THINGS,

AND SOME OF THESE
YOU SAW LAST WEEK,

AND I WANT YOU TO PUT THEM
IN THE RIGHT GROUP, OKAY?

SO AS WE SAID, YOU CAN'T BE BOTH A PLANT AND AN ANIMAL.

I'M GOING TO MAKE IT
SO THESE RINGS ONLY TOUCH.

OKAY, WHERE DO YOU PUT --

YES!

HE'S KIND OF CRAZY.

SO WHICH RING
DOES STRIPEY GO IN?

HE'S AN ANIMAL.

AND HOW DO YOU KNOW THAT?

HE'S MOVING.

WHAT ABOUT THIS THING?

PLANT.

IT'S A PLANT.

IT'S A PLANT
'CAUSE IT HAS LEAVES

AND IT'S NOT REALLY MOVING

AND IT'S IN DIRT
AND IT'S GREEN.

POTATO.

PLANT.

BECAUSE LIKE A PLANT
GROWS IN THE GROUND.

IT GROWS
IN THE GROUND.

A PLANT GROWS THE POTATO
SO IT'S LIKE PART OF A PLANT.

A PLANT.

A SNAKE, IT'S AN ANIMAL.

IT'S AN ANIMAL, DEFINITELY.

IT DOESN'T LOOK LIKE HER.

RIGHT HERE,
IN THE ANIMAL SECTION,

'CAUSE SHE'S A PERSON.

AND PERSON'S ARE MORE LIKE ANIMALS THAN PLANTS.

THEY ARE ANIMALS.

OH, YEAH,
IF YOU THINK ABOUT IT,

THEY COULD BE AN ANIMAL.

PEOPLE ARE ANIMALS.

BECAUSE THEY BREATHE IN THE
SAME STUFF AS ANOTHER ANIMAL,

AND THEY, LIKE,
MOVE JUST LIKE ANOTHER ANIMAL.

Woman:
I'VE GOT ONE OTHER THING HERE.

WHAT?

MUSHROOMS.

PLANTS.

DEFINITELY.

THEY GROW IN THE GROUND.

THEY CAN'T MOVE.

SO YOU WANT ME TO PUT THEM
IN THE PLANTS CATEGORY?
YEAH.

DO YOU SEE ANYTHING ABOUT THEM THAT MAKES THEM NOT LIKE PLANTS?

THEY HAVE UMBRELLAS AT THE TOP, LIKE UMBRELLAS, KIND OF.

THEY LOOK DIFFERENT.

THEY GROW ON PLANTS, SO.

BUT THEY DO GROW
IN THE GROUND.

YEAH, IT'S A PLANT.

OKAY, I'M GOING TO PUT IT IN
THE PLANTS CATEGORY, ALL RIGHT?

FOR ALL LIVING THINGS,

DO THEY ALL FALL
INTO PLANTS AND ANIMALS,

OR COULD PUT ANOTHER RING THERE?

MM-MNM, NEVER.

NEVER IN OUR WHOLE LIVES
WILL WE DARE.

TWO LIVING THINGS
ARE PLANTS AND ANIMALS.

BUT THOSE AREN'T
THE ONLY TWO LIVING THINGS.

WHAT OTHER LIVING THINGS
ARE THERE?

BACTERIA!

BACTERIA.

YEAH, BACTERIA
IS A LIVING THING.

Woman: AND WOULD THAT BE A PLANT OR ANIMAL OR SOMETHING ELSE?

THEY'RE SOMETHING ELSE.

I THINK IT WOULD BE
SOMETHING ELSE.

IT'S JUST A TINY
MICROSCOPIC THING THAT,

YOU KNOW,
IS A LIVING THING.

AND SO I COULD PUT
THIS RING HERE,

AND YOU'D PUT BACTERIA IN IT?

WE WOULDN'T SEE THE BACTERIA, 'CAUSE IT'S MICROSCOPIC.

WE'D ONLY SEE IT
WITH A MICROSCOPE, BUT.

SO IF WE HAD A MICROSCOPE

WE'D SEE THE BACTERIA
IN THIS RING,

BUT WE WOULDN'T SEE
WITHOUT A MICROSCOPE.

SO WITHOUT A MICROSCOPE
THIS RING WOULD LOOK EMPTY,

BUT THERE MIGHT BE A BACTERIA,
THERE'S BACTERIA ALL AROUND,

SO THERE MIGHT BE
BACTERIA RIGHT HERE, SO.

SO THERE REALLY IS
BACTERIA IN THE RING?

YEAH.

Zook: AND WHAT ABOUT BACTERIA
AND OTHER LIFE FORMS

THAT AREN'T
AS FAMILIAR TO US?

WHERE DO THEY FIT IN?

DR. COLLEEN CAVANAUGH
STUDIES ORGANISMS

THAT LIVE AROUND HYDROTHERMAL VENTS IN THE DEEP SEA.

AMONG THEM ARE SOME
OF THE "OTHERS"

THAT CHILDREN IN
THE SCIENCE STUDIO TALKED ABOUT.

I LOVE BACTERIA,

THAT'S WHAT I WORK ON

AND THE FACT THAT THEY ARE,
THEY HAVE SUCH A BAD NAME

BECAUSE YOU ALWAYS
THINK OF THEM AS GERMS

AND YET THEY RUN
THE BIOGEOCHEMICAL CYCLES,

THE NITROGEN CYCLE, THE CARBON,

THE HYDROGEN, JUST EVERYTHING,

AND IT'S THEIR EVOLUTION

AND INTERACTION
WITH THE NATURAL ENVIRONMENT

OVER BILLIONS OF YEARS

THAT HAVE SHAPED
WHERE WE ARE NOW.

AND YET
THE DIVERSITY IS UNKNOWN.

YOU KNOW, WE TALK ABOUT
HOW MANY BEETLES THERE ARE.

WELL, FOR BACTERIA
THERE ARE ONE MILLION

PER MILLILITER OF FRESH WATER,
OR SEAWATER.

SO WE HAVE NO IDEA
WHO IS OUT THERE.

THE DEEP SEA WAS THOUGHT TO BE

BASICALLY A BIOLOGICAL DESERT.

THE REASON BEING
THAT ALL THE FOOD IS PRODUCED

AT THE SURFACE
VIA PHOTOSYNTHESIS --

ALGAL, ALGAE,

AND THEN THE FOOD CHAIN
KIND OF EATS EVERYTHING UP THERE

AND THERE'S VERY LITTLE
THAT WILL GET TO THE DEEP SEA.

WE ARE TALKING
2 1/2, 3 1/2 KILOMETERS DOWN.

IT WASN'T ONLY THAT THERE WAS
NO FOOD GETTING THERE,

IT'S THAT YOU HAVE
VERY HIGH PRESSURES

AND THE NEAR-FREEZING TEMPERATURES OF THE OCEAN FLOOR.

LOW AND BEHOLD WE FOUND
THAT THE VENTS

THAT WERE INITIALLY DISCOVERED

OFF THE COAST

OF THE GALAPAGOS ISLANDS

HAD THESE AMAZING
JUST FIELDS OF TUBE WORMS

AND THIS WAS THE FIRST DISCOVERY
OF THESE --

THEY ARE JOINED
BY GIANT CLAMS AND MUSSELS,

LIMPETS ON THE TUBES

AND BACTERIA AND MICROORGANISMS.

THEY'RE ALL NEW SPECIES,

I THINK THERE'S BEEN OVER 400 NEW SPECIES DESCRIBED.

THE MAJORITY
ARE ENDEMIC TO THE VENTS,

THAT IS
THEY ARE ONLY FOUND AT VENTS,

THEY ARE NOT FOUND
IN DREDGES OF DEEP SEA,

YOU KNOW,
TYPICAL DEEP SEA SEDIMENT,

SO IT'S AN ECOSYSTEM
THAT HAS EVOLVED

VERY FOCUSED ON THESE
HOT SPRINGS AND VENTS.

THE WAY VENTS WORK --
YOU HAVE TO REMEMBER THAT

WE ARE ON CONTINENTAL PLATES THAT ARE SPREADING APART

AND ASSOCIATED WITH THAT
IS A LOT OF VOLCANIC ACTIVITIES

AND SEAWATER PERCOLATES
INTO THE EARTH,

IS SUPERHEATED
BY INTERACTION WITH LAVA

AND THESE ARE COMING UP
IN THIS VENT

AS WELL AS VOLCANIC GASES,
YOU KNOW,

GASES THAT YOU TYPICALLY
ASSOCIATE WITH A VOLCANO

SUCH AS METHANE AND CO2

AND THEN WITH THE OXYGEN
IN THE DEEP SEA WATER

CREATES THE PERFECT INTERFACE
FOR LIFE IN THE DEEP SEA.

WITH THE DISCOVERY OF THE VENTS

AND THESE OASES OF ANIMALS SURROUNDING THESE HOT SPRINGS,

IT WAS PROPOSED,
AND HAS SUBSEQUENTLY BEEN SHOWN,

THAT THESE ECOSYSTEMS

ARE BASED ON CHEMOSYNTHESIS

RATHER THAN PHOTOSYNTHESIS.

SO THE BACTERIA HERE
ARE EXTREME-HEAT LOVING BACTERIA

THAT WILL GROW
AT 115 DEGREES CELSIUS.

SO THIS IS ABOVE BOILING.

AND THESE BACTERIA CAN USE INORGANIC SUBSTANCES

LIKE HYDROGEN, IRON, SULFIDE,

THAT ARE IN THIS VENT EFFLUENT, THAT'S THEIR ENERGY SOURCE,

AND THEY'RE FIXING

CARBON DIOXIDE
INTO ORGANIC FOOD.

SO THEY ARE NOT DEPENDENT
ON SUNLIGHT.

BACTERIA ARE INCREDIBLE
BECAUSE THEY CAN USE ANYTHING,

VIRTUALLY, WITH THE EXCEPTION
OF A FEW MANMADE PLASTICS,

AS A CARBON
AND/OR ENERGY SOURCE.

IN THE REAL WORLD,
NOTHING LIVES IN ISOLATION.

YOU AND I HAVE MORE BACTERIAL AND OTHER ORGANISMS, SYMBIONTS,

THAN THE NUMBER OF CELLS
OF YOUR BODY.

YOUR MICROBIAL SYMBIONTS OUTNUMBER THE HUMAN CELLS.

SO THERE IS THIS WHOLE
UNTOLD DIVERSITY

THAT IS RUNNING OUR ATMOSPHERE

AND THAT ARE THE POTENTIAL
FOR ANTIBIOTICS.

AND WE SIMPLY
DON'T EVEN KNOW WHO THEY ARE,

WE TALK ABOUT
LOSING THE RAINFOREST SPECIES

BEFORE WE KNOW WHAT THEY ARE,
WELL, YOU'RE LOSING

THE WHOLE MICROFLORA
ASSOCIATED WITH EACH ONE

AND JUST BY PUTTING GRASS,
IN YOUR SOIL --

PUTTING GRASS OUT ON YOUR LAWN

YOU'RE CHANGING
THE WHOLE ECOSYSTEM BELOW THAT

AND WE JUST HAVE NO IDEA
WHAT IT IS

AND NO APPRECIATION OF IT,
THAT'S WHAT FRUSTRATES ME.

UP UNTIL ABOUT 20 YEARS AGO

WE DID NOT KNOW
WHO THE BACTERIA WERE.

INITIALLY THERE WAS SIMPLY
PLANTS AND ANIMALS,

AND THEN IT BECAME ONCE,

YOU KNOW,
SMALL ORGANISMS WERE DISCOVERED,

ANTONY VAN LEEUWENHOEK
CREATED THE FIRST MICROSCOPE

AND YOU COULD ACTUALLY SEE PROTISTS AND BACTERIA...

THAN THERE WERE THREE THINGS.

IT WAS KIND OF ANIMALS,
BACTERIA, AND MICROORGANISMS.

AND THEN OVER TIME,
IT BECAME CLEAR MORPHOLOGICALLY

THAT THINGS LIKE FUNGUS
WERE DIFFERENT

THAN SINGLE CELLED ORGANISMS
THAT HAD A NUCLEUS

VERSUS BACTERIA,

AND THAT'S KIND OF
WHERE WE'VE BEEN,

AND A LOT OF TEXTBOOKS
STILL ARE --

THE SO CALLED FIVE KINGDOMS --

BACTERIA, PROTISTS, FUNGI,
PLANTS, AND ANIMALS.

AND IT WAS KIND OF
ALWAYS ASSUMED

THAT ALL THESE THINGS
EVOLVED FROM BACTERIA.

NOW WITH THIS REVOLUTION
IN UNDERSTANDING

THE ORIGIN AND EVOLUTION OF LIFE

IT WAS SHOWN
THAT THE PROKARYOTES,

WITHOUT A NUCLEUS,

ACTUALLY WERE DIVIDED
INTO TWO MAJOR GROUPS

THAT ARE NOW REFERRED TO
AS DOMAINS --

ONE IS CALLED BACTERIA,
OR EUBACTERIA.

THE OTHER ONE IS CALLED
ARCHAEA BACTERIA.

AND THE IDEA FOR ARCHAEA
WAS OLD,

THEY LIVED DURING
THE EARLY STAGES OF THE EARTH,

WHEN IT WAS AN
ANAEROBIC ENVIRONMENT,

THERE WAS NO OXYGEN YET.

IF YOU THINK ABOUT IT,

BACTERIA WERE INTERACTING
WITH THE EARTH.

THEY BASICALLY
HAD THE ATMOSPHERE, THE LAND,

THE WATER TO INTERACT WITH.

I MEAN, THESE ALL BECOME
PART OF THE ENVIRONMENT

FOR OTHER ORGANISMS,
AND IT ISN'T JUST, YOU KNOW,

WHEN YOU TALK ABOUT
HUMAN SYMBIOSIS

AND THE BONDS
AND INTERACTIONS BETWEEN PEOPLE,

THERE IS JUST SUCH REMARKABLE
INTERACTIONS GOING ON,

MUCH OF WHICH WE DON'T SEE
BECAUSE THE MICROBIAL WORLD

IS NOT
RIGHT IN FRONT OF OUR EYES.

IS MAKES YOU RE-THINK
THE ORIGIN OF LIFE.

IT'S A VERY DIFFERENT
WAY OF THINKING,

REALLY IT CHANGES YOUR
WHOLE VIEW OF BIODIVERSITY

AND HOW YOU SHOULD BE
THINKING ABOUT IT.

IT SEEMS THAT PLANTS AND ANIMALS
HAVE AN AWFUL LOT OF COMPANY.

THERE ARE QUITE A FEW "OTHERS"
IN OUR MIDST.

SO LET'S REORGANIZE OUR OUTLINE

TO REFLECT CURRENT IDEAS
IN BIOLOGICAL CLASSIFICATION.

THERE ARE THREE DOMAINS,

AND ALL LIFE FORMS ARE CLASSIFIED INTO ONE OF THEM.

THE NEXT LEVEL OF CLASSIFICATION IS THE KINGDOM.

WITHIN THE DOMAIN EUKARYA

ARE THE PLANTS, ANIMALS,
FUNGI, AND PROTISTS.

CLASSIFICATION
AT THE KINGDOM LEVEL

IN THE BACTERIA AND ARCHAEA
IS STILL CHANGING,

AS SCIENTISTS DISCOVER
THE VAST DIVERSITY

OF PREVIOUSLY UNKNOWN SPECIES.

IT'S IMPORTANT TO UNDERSTAND

THAT STRATEGIES USED
FOR CLASSIFICATION

AND THE GROUPINGS THAT RESULT ARE SUBJECT TO CHANGE.

EVEN IN USING
OUR CLASSIFICATION STRATEGY,

THERE ARE SOME EXCEPTIONS.

NOT ALL PLANTS, FOR EXAMPLE,
ARE PHOTOSYNTHETIC.

THE STRATEGY WE USED WAS BASED
ON GENERAL CELL CHARACTERISTICS.

WE'LL EXPAND UPON
THE CHARACTERISTICS

WE USE TO CLASSIFY
IN FUTURE SESSIONS,

AND SEE HOW CLASSIFICATION

IS A DYNAMIC
AND EXCITING ENDEAVOR.

YOU MAY BE WONDERING HOW
TO BRING SOME OF THE "OTHERS"

INTO YOUR TEACHING --

LIFE FORMS THAT
ARE NOT PLANTS OR ANIMALS.

FUNGI ARE FOUND
IN MANY PLACES,

AND CAN BE TRANSPORTED EASILY INTO THE CLASSROOM.

EVEN A SLICE OF BREAD CAN BE

A "FUNGAL EXPERIENCE"
FOR YOUR STUDENTS.

Zook: A MICROSCOPE AND
A DROP OF WATER FROM A POND

IS ALL YOU NEED TO INTRODUCE
THE REMARKABLE WORLD OF PROTISTS

TO YOUR STUDENTS.

Grisham: BACTERIA ARE
A BIT OF A CHALLENGE.

BUT YOU CAN CULTURE BACTERIA, USING BROTH, OR GELATIN,

AND PRODUCE LARGE NUMBERS
THAT YOU CAN SEE.

GO TO OUR WEB SITE
FOR TEACHING TIPS

ON HOW TO BRING SOME OF THESE "OTHERS" INTO YOUR CLASSROOM.

DURING THIS SESSION
WE FOCUSED ON MAKING SENSE

OF THE LIVING WORLD
THROUGH A SYSTEMATIC APPROACH

TO BIOLOGICAL CLASSIFICATION.

NEXT SESSION,
WE'LL TAKE A CLOSER LOOK

AT THE KINGDOM
WE ALL BELONG TO --

THE ANIMALS.

THANKS FOR BEING WITH US.

SEE YOU NEXT TIME.

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