

--> Display at 01:00:00:11

--> Display at 01:00:05:05
FUNDING FOR THIS PROGRAM
IS PROVIDED BY ANNENBERG/CPB

--> Display at 01:00:09:07
--> Erase at 01:00:13:04
TO ADVANCE EXCELLENT TEACHING.

--> Display at 01:00:32:09
Narrator: WHAT'S ON TONIGHT'S MENU FOR ROTIFERS AND MIDGES?

--> Display at 01:00:37:07
HOW ABOUT A FAMILY OF GEESE,

--> Display at 01:00:40:14
OR THESE LEAFY PLANTS?

--> Display at 01:00:44:07
WHAT WILL THEY DO FOR FOOD?

--> Display at 01:00:46:20
FOR ALL LIVING THINGS,
FROM FALCONS TO FUNGI,

--> Display at 01:00:52:19
THE MENU OPTIONS AND LIMITS DEPEND

--> Display at 01:00:54:24
ON WHERE AN ORGANISM FITS
INTO THE LOCAL FOOD CHAIN.

--> Display at 01:00:57:26
BUT WHAT DOES THAT REALLY MEAN?

--> Display at 01:01:01:06
WHY ARE SOME ORGANISMS
LINKED BY FOOD?

--> Display at 01:01:05:16
AND HOW IS IT THAT FOOD CHAINS INCLUDE CREATURES

--> Display at 01:01:07:23
THAT CAN'T EVEN EAT?

--> Display at 01:01:09:04
THE FOOD CHAIN IS
A DECEPTIVELY SIMPLE IDEA,

--> Display at 01:01:12:29
BECAUSE THE FOOD CHAIN ISN'T REALLY ABOUT FOOD.

--> Display at 01:01:15:21
IT'S ABOUT ENERGY.

--> Display at 01:01:18:03
HOW DIFFERENT ORGANISMS
ACQUIRE IT,

--> Display at 01:01:20:19
WHAT THEY USE IT FOR,

--> Display at 01:01:22:22
AND WHERE IT GOES.

--> Display at 01:01:26:27
--> Erase at 01:01:30:14
WHERE DOES ENERGY
IN THE LIVING WORLD COME FROM?

--> Display at 01:01:50:18
HELLO, AND WELCOME BACK TO "ESSENTIAL SCIENCE."

--> Display at 01:01:53:26
THIS IS SESSION 7
IN THE LIFE SCIENCE SERIES,

--> Display at 01:01:57:07
A CONTENT COURSE
FOR ELEMENTARY SCHOOL TEACHERS.

--> Display at 01:02:00:22
IN PREVIOUS SESSIONS,

--> Display at 01:02:02:19
WE'VE EXPLORED THE LIFE CYCLES OF PLANTS AND ANIMALS.

--> Display at 01:02:05:19
AND WE'VE LOOKED
AT THE TREE OF LIFE

--> Display at 01:02:07:28
AS A MODEL
FOR UNDERSTANDING

--> Display at 01:02:09:19
THE EVOLUTIONARY HISTORY
OF LIFE ON EARTH.

--> Display at 01:02:14:01
TODAY WE'LL CONTINUE
TO BUILD ON THESE THEMES

--> Display at 01:02:15:26
BY CONSIDERING COMMUNITIES
OF ANIMALS AND PLANTS

--> Display at 01:02:18:09
THAT SHARE
THE SAME ENVIRONMENT.

--> Display at 01:02:20:22

IF WE TOOK
A SHORT WALK OUTSIDE,

--> Display at 01:02:23:02
CHANCES ARE WE'D SEE SIGNS
OF COMMUNITY INTERACTIONS.

--> Display at 01:02:27:05
DEPENDING UPON
WHERE WE HAPPENED TO BE,

--> Display at 01:02:28:20
WE MAY SEE A FOREST,

--> Display at 01:02:30:24
PERHAPS A DESERT,
OR EVEN AN OCEAN REEF.

--> Display at 01:02:32:26
IN MORE URBAN SETTINGS, YOU'LL FIND COMMUNITIES IN PARKS,

--> Display at 01:02:37:05
AND ALSO IN GUTTERS AND PUDDLES.

--> Display at 01:02:41:06
COMMUNITIES ARE
POPULATIONS

--> Display at 01:02:42:16
THAT ARE LINKED IN WAYS

--> Display at 01:02:43:26
THAT SUPPORT THE SURVIVAL
OF ITS MEMBERS.

--> Display at 01:02:46:08
WE'VE ALREADY SEEN
EXAMPLES OF CREATURES

--> Display at 01:02:48:18
THAT UNWITTINGLY
HELP EACH OTHER --

--> Display at 01:02:50:18
ORGANISMS WHOSE LIVES
INTERSECT IN WAYS

--> Display at 01:02:53:08
THAT INCREASE
EACH OTHER'S CHANCES

--> Display at 01:02:55:20
FOR REPRODUCTIVE SUCCESS
AND SURVIVAL.

--> Display at 01:02:58:08
THE INTERTWINED

LIFE CYCLES

--> Display at 01:03:00:29
OF BEES AND FLOWERS,
FOR EXAMPLE,

--> Display at 01:03:04:04
OR THE SYMBIOTIC PARTNERSHIP
OF FUNGI AND ALGAE IN LICHEN.

--> Display at 01:03:07:27
ANOTHER RELATIONSHIP
IN THE NATURAL WORLD

--> Display at 01:03:10:14
IS THE PREDATOR-PREY RELATIONSHIP.

--> Display at 01:03:12:20
HARDLY RECIPROCAL,
BUT ESSENTIAL

--> Display at 01:03:15:06
TO THE ONGOING
LIFE OF COMMUNITIES.

--> Display at 01:03:17:27
IN OUR FIRST SESSION,
WE SAW THAT CONSTANT SUPPLIES

--> Display at 01:03:21:16
OF MATTER AND ENERGY
ARE REQUIREMENTS OF LIFE.

--> Display at 01:03:24:03
IN THIS SESSION, WE'RE GOING
TO TRACE THE FLOW OF ENERGY

--> Display at 01:03:27:04
THROUGH COMMUNITIES
LIKE THE ONES WE JUST MENTIONED,

--> Display at 01:03:30:02
USING THE CONCEPT
OF FOOD CHAINS.

--> Display at 01:03:33:05
TODAY WE'LL START BY ASKING
SOME GENERAL QUESTIONS

--> Display at 01:03:35:27
ABOUT ENERGY AND LIFE.

--> Display at 01:03:37:26
THEN WE WILL LOOK AT HOW ENERGY IS ACQUIRED AND USED

--> Display at 01:03:41:06
AS IT MOVES THROUGH LINKS

IN FOOD CHAINS,

--> Display at 01:03:43:19
FROM PRODUCERS TO CONSUMERS,
AND TO DECOMPOSERS.

--> Display at 01:03:49:13
Grisham: PERIODICALLY,
WE'LL NARROW OUR FOCUS

--> Display at 01:03:51:21
TO THE CELLULAR LEVEL,
TO CONSIDER

--> Display at 01:03:53:27
HOW ENERGY AT WORK IN CELLS

--> Display at 01:03:55:25
MAKES ENERGY FLOW

--> Display at 01:03:57:15
WITHIN COMMUNITIES
POSSIBLE.

--> Display at 01:03:59:09
OUR INVESTIGATION
WILL LEAD US TO ASK

--> Display at 01:04:02:26
--> Erase at 01:04:04:25
SOME CHALLENGING QUESTIONS,
LIKE --

--> Display at 01:04:12:19
THESE QUESTIONS ARE PART OF
AN ELEMENTARY SCHOOL CURRICULUM

--> Display at 01:04:15:27
DEVELOPED BY DR. HERBERT THIER,

--> Display at 01:04:18:15
--> Erase at 01:04:22:06
A CO-AUTHOR OF THE SCIENCE CURRICULUM IMPROVEMENT STUDY.

--> Display at 01:04:28:02
AT THIS 5th-GRADE LEVEL --
AND THIS GETS LIFE SCIENCE --

--> Display at 01:04:32:03
WE ARE TRYING TO GET
THE STUDENTS TO FOCUS IN

--> Display at 01:04:35:10
ON THIS FUNDAMENTAL INTERACTION

--> Display at 01:04:37:14
BETWEEN ORGANISMS

AND THEIR ENVIRONMENT.

--> Display at 01:04:41:05
SO WE FIRST GET THEM
TO UNDERSTAND A FOOD CHAIN,

--> Display at 01:04:43:22
AND THEN A FOOD WEB.

--> Display at 01:04:45:03
AND THAT'S VERY OBVIOUS.

--> Display at 01:04:46:13
YOU SEE THE FOOD BEING EATEN.

--> Display at 01:04:48:16
BIGGER ANIMALS EAT
LITTLE ANIMALS, ET CETERA.

--> Display at 01:04:51:11
WE EAT FISH,
THE FISH EAT SMALLER FISH.

--> Display at 01:04:54:18
THE PLANTS ARE FOOD
FOR THE CRICKETS,

--> Display at 01:04:56:26
SO WE PUT IT ON THAT LINE,
AND THEN --

--> Display at 01:04:59:02
Teacher: YOU MEAN,
LIKE HOW IT IS?

--> Display at 01:05:01:04
YEAH, AND THEN WE THOUGHT,

--> Display at 01:05:03:08
THE CRICKETS AND
THE MEALWORMS AND STUFF,

--> Display at 01:05:05:04
WERE THE FOOD
FOR THE CHAMELEON.

--> Display at 01:05:07:20
BUT NOW WE ASK, "WELL, WHY IS ALL OF THIS EATING GOING ON?"

--> Display at 01:05:12:07
THIS EATING IS GOING ON TO PROVIDE ORGANISMS WITH ENERGY

--> Display at 01:05:17:09
SO THAT THEY CAN GO THROUGH
LIFE CYCLES, REPRODUCE,

--> Display at 01:05:22:18

AND THAT THE WHOLE COMMUNITY
CAN CONTINUE.

--> Display at 01:05:28:06
ONE OF THE BIG INTERACTIONS

--> Display at 01:05:30:07
WE ARE VERY CONCERNED ABOUT

--> Display at 01:05:32:02
IS THE TRANSFER OF ENERGY

--> Display at 01:05:33:25
IN AN ECOSYSTEM OR COMMUNITY

--> Display at 01:05:37:26
BETWEEN THE PRODUCERS, CONSUMERS, AND DECOMPOSERS.

--> Display at 01:05:41:28
AND IT IS THAT TRANSFER
OF ENERGY

--> Display at 01:05:44:21
THAT IS CRITICAL TO THE ONGOING LIFE OF THE COMMUNITY.

--> Display at 01:05:49:20
Grisham: IN MELISSA MINNICK'S 5th-GRADE CLASS,

--> Display at 01:05:53:03
STUDENTS SET UP TERRARIUMS SEVERAL WEEKS AGO.

--> Display at 01:05:55:26
EACH TERRARIUM HOUSES
A COMMUNITY

--> Display at 01:05:59:16
MADE UP OF ANOLES --
A TYPE OF CHAMELEON --

--> Display at 01:06:02:09
CRICKETS, ISOPODS, MEALWORMS, AND BEET AND MUSTARD SEEDS.

--> Display at 01:06:05:26
THEY'VE BEEN WATCHING
THEIR COMMUNITIES,

--> Display at 01:06:09:08
RECORDING THE INTERACTIONS

--> Display at 01:06:10:19
IN THEIR TERRARIUMS,
AND BUILDING A COMMUNITY CHART

--> Display at 01:06:14:04
BASED ON THEIR OBSERVATIONS.

--> Display at 01:06:16:13

THEY STARTED OFF
BY WORKING IN THEIR GROUPS

--> Display at 01:06:18:14
AND OBSERVING THEIR TERRARIA.

--> Display at 01:06:19:24
AND ALL GROUPS TOOK A LOOK
AT THE CHANGES

--> Display at 01:06:22:16
THAT WERE GOING ON
IN THEIR TERRARIA.

--> Display at 01:06:24:27
THE THING IS,
IS THAT THE TERRARIUM,

--> Display at 01:06:27:04
IT'S PROBABLY MORE,
IT'S NOT REALLY EDIBLE.

--> Display at 01:06:32:27
BUT THE BRAN IS,
AND SO ARE STRAWBERRIES,

--> Display at 01:06:36:06
AND SO IS BREAD.

--> Display at 01:06:37:17
SO THEN PROBABLY,
IF IT'S EDIBLE,

--> Display at 01:06:39:08
THE MOLD WILL EAT IT.

--> Display at 01:06:40:18
I LIKE TO SEE THE STUDENTS COUNT THE AMOUNT OF CRICKETS

--> Display at 01:06:43:15
THAT ARE LEFT AND COUNT
THE AMOUNT OF MEALWORMS,

--> Display at 01:06:45:28
BECAUSE THAT SHOWS ME

--> Display at 01:06:47:08
THAT THEY'RE THINKING
ABOUT THE FOOD CHAIN,

--> Display at 01:06:49:17
AND THEY'RE THINKING
ABOUT THE TRANSFER OF ENERGY,

--> Display at 01:06:52:05
AND THEY'RE WONDERING
MORE ABOUT THAT --

--> Display at 01:06:53:24
"WHAT DID MY ANOLE EAT TODAY?"

--> Display at 01:06:55:06
WAS IT DIFFERENT THAN YESTERDAY?"

--> Display at 01:06:56:28
SO I LIKE TO SEE THAT,

--> Display at 01:06:58:09
THAT THEY'RE THINKING
ABOUT THE ENERGY TRANSFER,

--> Display at 01:07:00:02
BECAUSE THAT'S ONE
OF THE MAIN

--> Display at 01:07:01:12
CONCEPTS
THAT I WANT TO GET ACROSS.

--> Display at 01:07:02:24
Narrator: AFTER THE STUDENTS HAVE SHARED THEIR OBSERVATIONS,

--> Display at 01:07:06:20
THEY'RE ASKED TO THINK

--> Display at 01:07:08:00
ABOUT HOW THE ORGANISMS
IN THEIR TERRARIUMS

--> Display at 01:07:10:10
ARE LINKED THROUGH FOOD CHAINS.

--> Display at 01:07:12:09
Minnick: SO WHERE DO YOU THINK I'M GOING TO PUT MY FOOD LABEL?

--> Display at 01:07:14:15
WHY DON'T YOU COME UP HERE
AND PUT IT UP, TOO?

--> Display at 01:07:16:10
WHERE DO YOU THINK
IT WOULD GO?

--> Display at 01:07:17:20
I THINK IT WOULD GO...

--> Display at 01:07:19:04
RIGHT ABOUT IN HERE, BECAUSE THAT'S WHAT, PRETTY MUCH --

--> Display at 01:07:22:10
'CAUSE THE CHAMELEON HAS
TO EAT THE ISOPODS THAT --

--> Display at 01:07:27:13

OR THE CRICKETS
THAT EAT THE FOOD --

--> Display at 01:07:31:07
THIS IS KIND OF ALL
THE FOOD FOR EVERYTHING.

--> Display at 01:07:34:02
Minnick: RIGHT,
SO HOW ABOUT --

--> Display at 01:07:35:21
THIS IS AN IDEA, HOW ABOUT
IF WE PUT THE FOOD LABEL

--> Display at 01:07:38:04
IN BETWEEN THESE TWO,
SO WE CAN KIND OF SEE,

--> Display at 01:07:40:08
LIKE, THIS IS FOOD FOR THIS, DOES THAT MAKE SENSE?

--> Display at 01:07:42:18
YEAH.

--> Display at 01:07:43:28
NOW, WHAT
ABOUT THIS LAST ONE?

--> Display at 01:07:46:19
I THOUGHT THIS WOULD
TRICK SOME PEOPLE.

--> Display at 01:07:48:16
VERONICA, I KNOW YOU GOT
REALLY EXCITED ABOUT THIS.

--> Display at 01:07:50:19
SO WHY DON'T YOU COME UP
AND SHARE IT?

--> Display at 01:07:52:06
WHERE ARE YOU
GOING TO PUT IT?

--> Display at 01:07:54:09
I'M GOING
TO PUT IT IN BETWEEN.

--> Display at 01:07:56:15
I'M GOING TO PUT IT IN BETWEEN THE MOLDS AND BACTERIAS

--> Display at 01:07:59:27
AND THE OTHER ORGANISMS,
BECAUSE OF THE REASON

--> Display at 01:08:03:17

THAT THE MOLDS AND BACTERIA,

--> Display at 01:08:05:27
IT EATS ALL OF THESE THINGS
WHEN THEY DIE.

--> Display at 01:08:09:14
AND SO THAT'S BASICALLY WHY.

--> Display at 01:08:12:22
Minnick: SO ALL THREE
OF THOSE ORGANISMS

--> Display at 01:08:15:05
ARE FOOD
FOR MOLD AND BACTERIA.

--> Display at 01:08:17:05
AWESOME.
VERY GOOD.

--> Display at 01:08:18:19
THE CHILDREN
IN MELISSA MINNICK'S CLASSROOM

--> Display at 01:08:20:23
HAVE DEVELOPED
A STRONG UNDERSTANDING

--> Display at 01:08:22:25
OF THE SIMPLE FOOD CHAINS
THAT EXIST IN THEIR TERRARIUMS.

--> Display at 01:08:25:23
THEY CAN IDENTIFY WHO EATS WHAT, AND TRACE

--> Display at 01:08:29:08
THE PATH OF FOOD
WITHIN THEIR COMMUNITIES.

--> Display at 01:08:31:29
THIS IS A GOOD START
TO UNDERSTANDING

--> Display at 01:08:33:17
THE FLOW OF ENERGY
THROUGH A COMMUNITY,

--> Display at 01:08:35:09
SOMETHING OFTEN OVERLOOKED
BY STUDENTS.

--> Display at 01:08:38:20
SO WE ASKED THE STUDENTS
IN OUR SCIENCE STUDIO

--> Display at 01:08:40:24

SPECIFICALLY ABOUT ENERGY,

--> Display at 01:08:42:18
--> Erase at 01:08:46:04
TO SEE IF THEY CONNECT IT
TO THE CONCEPT OF FOOD.

--> Display at 01:08:53:07
CAN YOU TELL ME
WHAT ENERGY IS, TO YOU?

--> Display at 01:08:56:05
Boy: WHEW!

--> Display at 01:08:57:17
WE'VE SPENT THREE WEEKS
IN SCIENCE

--> Display at 01:08:59:26
WRITING THE DEFINITION
OF ENERGY.

--> Display at 01:09:02:22
[Maggy gasps]
THE ABILITY...

--> Display at 01:09:04:24
Both: TO CAUSE MOTION
OR CREATE CHANGE!

--> Display at 01:09:06:29
I SEE YOU'VE MEMORIZED
THAT DEFINITION.

--> Display at 01:09:08:12
WHAT DOES THAT MEAN?

--> Display at 01:09:09:22
IT'S WHEN YOU,
IT'S, ENERGY IS, IS...

--> Display at 01:09:16:06
IT MAKES, IT CAUSES MOTION
AND CREATES CHANGE?

--> Display at 01:09:20:11
[MAGGY LAUGHS]

--> Display at 01:09:21:25
AND THE WAY, LIKE, THESE LITTLE ANTS ARE CREATING ENERGY --

--> Display at 01:09:27:13
Maggy: CRICKETS.
WELL, CRICKETS --

--> Display at 01:09:29:20
BY RUBBING THEIR FEET

ON THE SOIL,

--> Display at 01:09:33:18
AND THE SOIL IS GETTING MOVED AROUND, AND THAT'S ENERGY.

--> Display at 01:09:37:21
KIND OF.

--> Display at 01:09:39:18
GREG AND MAGGY
RECITE A DEFINITION

--> Display at 01:09:41:17
THEY'VE LEARNED IN SCHOOL,

--> Display at 01:09:42:29
AND THEY DON'T SEEM
TO CONNECT ENERGY WITH FOOD.

--> Display at 01:09:46:19
BUT IT'S A DIFFICULT CONCEPT.

--> Display at 01:09:48:25
YOU CAN'T SEE ENERGY.

--> Display at 01:09:50:20
IT'S REALLY QUITE ELUSIVE.

--> Display at 01:09:53:27
BUT WITHOUT IT,
ALL LIFE COMES TO A HALT.

--> Display at 01:09:57:17
LET'S SEE WHAT THEY SAY
ABOUT ENERGY AND LIFE.

--> Display at 01:10:00:22
Greg: WATER MIGHT BE ENERGY, BECAUSE WHEN YOU DRINK ENERGY --

--> Display at 01:10:04:07
OH, YEAH, WHEN YOU DRINK
WATER, IT'S NUTRIENTS.

--> Display at 01:10:07:01
BUT NUTRIENTS AREN'T
NECESSARILY ENERGY.

--> Display at 01:10:09:25
NUTRIENTS ARE MORE
OF A CAUSE OF ENERGY, TOO.

--> Display at 01:10:12:12
SO IT CAN BE USED AS A CAUSE
OF ENERGY IN TWO WAYS.

--> Display at 01:10:15:12
OF NUTRIENTS,

AND OF FRICTION, OR --

--> Display at 01:10:19:07
BECAUSE IT CAN
CREATE FRICTION

--> Display at 01:10:21:12
WHEN APPLIED
TO THE RIGHT RESOURCES,

--> Display at 01:10:23:06
LIKE GEARS AND MECHANISMS

--> Display at 01:10:25:06
AND MECHANICAL STUFF
LIKE THAT.

--> Display at 01:10:26:16
WHAT IF I DRANK IT?

--> Display at 01:10:27:26
WOULD IT CAUSE
ENERGY IN ME?

--> Display at 01:10:29:18
YEAH, IT WOULD
GIVE YOU NUTRIENTS,

--> Display at 01:10:31:16
AND NUTRIENTS CAUSE
ENERGY IN YOUR BODY.

--> Display at 01:10:33:29
SO THAT WOULD
GIVE YOU ENERGY.

--> Display at 01:10:35:29
Abrams: YOU SAID SOMETHING
ABOUT NUTRIENTS CAUSING ENERGY.

--> Display at 01:10:38:11
DO YOU KNOW HOW
THEY CAUSE ENERGY?

--> Display at 01:10:41:10
NOT REALLY.
Maggy: I THINK
NUTRIENTS ARE ENERGY.

--> Display at 01:10:45:01
NO, THEY JUST
CAUSE ENERGY.

--> Display at 01:10:47:04
BECAUSE NUTRIENTS
ARE JUST NUTRIENTS.

--> Display at 01:10:49:15
THEY'RE VITAMINS
AND MINERALS

--> Display at 01:10:52:09
THAT GIVE
ENOUGH ENERGY --

--> Display at 01:10:54:26
WELL, THEY --
THAT WHEN APPLIED

--> Display at 01:10:57:02
TO THE RIGHT RESOURCES,
LIKE WHAT'S,

--> Display at 01:10:59:16
THE CHEMICALS
IN YOUR BODY,

--> Display at 01:11:01:17
THEY CAN BECOME
GOOD ENERGY RESOURCES.

--> Display at 01:11:05:29
MANY TIMES, STUDENTS USE WORDS

--> Display at 01:11:08:10
LIKE "NUTRIENTS" AND "ENERGY"

--> Display at 01:11:10:19
THAT HAVE EVERYDAY MEANINGS

--> Display at 01:11:12:06
THAT ARE DIFFERENT
FROM THE SCIENTIFIC ONES.

--> Display at 01:11:15:04
FOR EXAMPLE,
CHILDREN MIGHT THINK

--> Display at 01:11:17:14
IF THEY DRINK PLENTY OF WATER,

--> Display at 01:11:19:09
THEY'LL HAVE MORE ENERGY.

--> Display at 01:11:21:11
WHICH COULD MEAN THEY'LL BE FASTER ON THE SOCCER FIELD.

--> Display at 01:11:24:11
THE CONFUSION BETWEEN ENERGY
AND NUTRIENTS ISN'T SURPRISING.

--> Display at 01:11:27:25
THE FACT IS, ALL FOOD CONTAINS ENERGY AND NUTRIENTS.

--> Display at 01:11:31:25
BUT THERE ARE IMPORTANT DIFFERENCES BETWEEN THEM.

--> Display at 01:11:34:29
WE'LL FOCUS ON NUTRIENTS AND
THE MATERIALS THAT MAKE UP LIFE

--> Display at 01:11:38:03
NEXT TIME, IN OUR FINAL SESSION.

--> Display at 01:11:40:08
IN THIS SESSION, WE'RE FOCUSING ON THE ENERGY STORED IN FOOD.

--> Display at 01:11:44:20
IN A SCIENTIFIC SENSE,

--> Display at 01:11:46:25
THE CONCEPT OF ENERGY
IS NARROWLY DEFINED.

--> Display at 01:11:49:15
THE ENERGY FOUND IN FOOD
IS MEASURED IN WAYS

--> Display at 01:11:52:29
FAMILIAR TO ANYONE WHO HAS EVER LOOKED AT A CEREAL BOX

--> Display at 01:11:56:19
OR DIETED --
CALORIES, WITH A BIG "C."

--> Display at 01:12:01:03
A CALORIE IS DEFINED
AS THE AMOUNT OF ENERGY

--> Display at 01:12:04:00
NEEDED TO RAISE THE TEMPERATURE OF ONE KILOGRAM OF WATER --

--> Display at 01:12:07:18
WHICH IS THE VOLUME
OF ONE LITER OF WATER --

--> Display at 01:12:10:24
UP BY ONE DEGREE CELSIUS.

--> Display at 01:12:14:00
Zook: AND IN BIOLOGICAL TERMS,

--> Display at 01:12:16:01
ONE CALORIE ISN'T VERY MUCH
FOR A HUMAN,

--> Display at 01:12:17:29
BUT IT'S ALL
THAT A HUMMINGBIRD NEEDS

--> Display at 01:12:19:24

TO KEEP HOVERING FOR AN HOUR.

--> Display at 01:12:22:07
ENERGY NEEDS VARY WIDELY.

--> Display at 01:12:24:15
A PERSON NEEDS
ABOUT 2,000 CALORIES A DAY

--> Display at 01:12:27:08
JUST TO STAY ALIVE.

--> Display at 01:12:29:20
AN ELEPHANT NEEDS
ABOUT 100,000.

--> Display at 01:12:33:13
WE PAID A VISIT
TO DR. LES KAUFMAN

--> Display at 01:12:35:26
TO FIND OUT HOW
ENERGY STORED IN FOOD

--> Display at 01:12:38:18
--> Erase at 01:12:41:13
IS USED TO FUEL
THE ACTIVITIES OF CELLS.

--> Display at 01:13:01:00
RIGHT NOW, AS I'M TALKING,

--> Display at 01:13:03:19
MY BODY IS RUNNING
OUT OF ENERGY.

--> Display at 01:13:05:28
AND I FEEL A TREMENDOUS NEED
FOR QUICK ENERGY.

--> Display at 01:13:09:20
NOW, I KNOW I HAVE AN AMPLE SUPPLY OF LONG-TERM ENERGY,

--> Display at 01:13:14:02
BUT I WANT SOME QUICK ENERGY.

--> Display at 01:13:15:24
I'D LIKE A MARSHMALLOW, PLEASE.

--> Display at 01:13:17:28
THANK YOU.
IT'S WONDERFUL OUT IN THE WOODS.

--> Display at 01:13:20:01
NATURE PROVIDES EVERYTHING.

--> Display at 01:13:21:21

OKAY, SO...

--> Display at 01:13:25:04
THIS MARSHMALLOW
IS ALMOST PURE SUGAR.

--> Display at 01:13:29:02
WHAT WE'RE GOING TO DO HERE
IS TAKE THE ENERGY

--> Display at 01:13:31:25
THAT IS LOCKED
IN THE ARRANGEMENT

--> Display at 01:13:34:17
OF THE ATOMS AND MOLECULES

--> Display at 01:13:36:19
IN THE SUGAR
IN THIS MARSHMALLOW.

--> Display at 01:13:38:26
AND WE'RE GOING TO CHANGE
THE FORM OF THE MATTER,

--> Display at 01:13:42:09
AND IN SO DOING,
RELEASE A LOT OF ENERGY.

--> Display at 01:13:45:26
NOW, WHEN I COOK
THE MARSHMALLOW,

--> Display at 01:13:49:03
I'M RELEASING THAT ENERGY
VERY, VERY QUICKLY.

--> Display at 01:13:51:21
JUST LIKE THE FIRE.

--> Display at 01:13:54:06
NOW, THE MARSHMALLOW
IS NO LONGER IN THE FIRE.

--> Display at 01:13:57:11
BUT IT'S STILL BURNING.

--> Display at 01:13:59:02
SO WHAT'S GOING ON

--> Display at 01:14:00:15
IS THAT THE BONDS IN THE SUGAR
ARE BEING BROKEN,

--> Display at 01:14:03:21
AND YOU SEE THE SAME THING HAPPENING AS IN THE FIRE,

--> Display at 01:14:06:29
IT'S PRODUCING
CARBON -- SOOT -- AND WATER.

--> Display at 01:14:09:23
NOW, I DON'T WANT
TO RUIN THIS MARSHMALLOW.

--> Display at 01:14:11:27
NOW, WHAT I'D LIKE TO DO

--> Display at 01:14:13:14
IS BURN THE REST
OF THE MARSHMALLOW,

--> Display at 01:14:15:09
MORE SLOWLY.

--> Display at 01:14:16:19
I SHOULD BE ABLE TO BURN
THIS MARSHMALLOW IN MY BODY

--> Display at 01:14:20:15
AND RELEASE THE ENERGY
CONTAINED IN THESE BONDS.

--> Display at 01:14:23:13
NOW, THE REARRANGEMENT
OF THE ATOMIC STRUCTURE

--> Display at 01:14:28:17
OF THE MARSHMALLOW IN MY BODY

--> Display at 01:14:30:16
IS ACTUALLY IDENTICAL, ULTIMATELY,

--> Display at 01:14:33:01
TO WHAT'S GOING ON IN THE FIRE.

--> Display at 01:14:35:26
IT'S JUST BROKEN DOWN
INTO A SERIES OF STEPS,

--> Display at 01:14:38:24
SO THAT ENERGY
IS NOT ONLY RELEASED,

--> Display at 01:14:42:05
BUT IT CAN BE RECAPTURED
IN OTHER CHEMICAL BONDS

--> Display at 01:14:46:11
THAT MY BODY CAN USE AT WILL.

--> Display at 01:14:49:11
MMM.

--> Display at 01:14:52:01
MMM, IT'S DELICIOUS,

--> Display at 01:14:55:12
EVEN THOUGH IT'S CARCINOGENIC.

--> Display at 01:14:57:14
MARSHMALLOWS SHOW
PRETTY DRAMATICALLY

--> Display at 01:15:00:16
HOW STORED ENERGY
CAN BE RELEASED FROM FOOD.

--> Display at 01:15:03:10
AND THE BURNING PROCESS

--> Display at 01:15:05:11
THAT RELEASES ENERGY
IN THE MARSHMALLOW

--> Display at 01:15:07:02
IS THE SAME PROCESS THAT
TAKES PLACE IN LIVING BODIES.

--> Display at 01:15:10:25
ENERGY IS RELEASED THAT
CAN BE USED IMMEDIATELY

--> Display at 01:15:13:09
OR STORED FOR LATER USE.

--> Display at 01:15:15:21
THE BIG, IMPORTANT DIFFERENCE
IS THE RATE OF BURNING.

--> Display at 01:15:18:12
IT IS VERY FAST IN THE FIRE.

--> Display at 01:15:20:04
IT IS MUCH SLOWER
IN LIVING ORGANISMS.

--> Display at 01:15:23:15
LET'S RETURN
TO DR. KAUFMAN

--> Display at 01:15:25:10
TO UNDERSTAND
WHY ECOLOGISTS

--> Display at 01:15:27:00
--> Erase at 01:15:29:15
ARE INTERESTED
IN ENERGY FLOW.

--> Display at 01:15:32:27

Kaufman: ECOLOGISTS
ARE INTERESTED

--> Display at 01:15:35:05
IN THIS FLOW OF ENERGY
FROM ONE ORGANISM TO ANOTHER,

--> Display at 01:15:37:26
FROM ONE PART OF THE SYSTEM
TO ANOTHER,

--> Display at 01:15:39:17
AND ALSO THE FLOW
OF MATERIALS --

--> Display at 01:15:42:02
THE STUFF, THE PROTEIN
AND OTHER CHEMICALS --

--> Display at 01:15:45:04
THAT WILL BUILD
NEW LIVING ORGANISMS.

--> Display at 01:15:47:26
SO EVEN THOUGH
WE CAN'T SEE THE ENERGY,

--> Display at 01:15:50:08
WE CAN IMAGINE THE WAY
THAT IT MOVES AROUND

--> Display at 01:15:52:26
IN LIVING SYSTEMS.

--> Display at 01:15:54:15
COMMUNITY IS A CONCEPT.

--> Display at 01:15:56:17
IT'S AN IDEA THAT WE USE
TO DRAW A BOUNDARY

--> Display at 01:15:59:21
AROUND A SMALL PART
OF THE LIVING WORLD,

--> Display at 01:16:02:21
SO WE CAN ASK QUESTIONS
ABOUT IT.

--> Display at 01:16:04:18
SO, THESE WOODS MIGHT
BE REGARDED AS A COMMUNITY.

--> Display at 01:16:08:26
ON THE OTHER HAND,

--> Display at 01:16:11:18

THIS LEAF IS
ITS OWN COMMUNITY.

--> Display at 01:16:14:02
IT HAS ORGANISMS INSIDE OF IT, STORING ENERGY,

--> Display at 01:16:17:13
TRANSFERRING THAT ENERGY
FROM ONE TO ANOTHER,

--> Display at 01:16:20:02
AND WHAT ECOLOGISTS
ARE MOST INTERESTED IN

--> Display at 01:16:23:13
ARE THE DYNAMICS OF A COMMUNITY.

--> Display at 01:16:26:06
WHAT ARE ALL THE THINGS
THAT CHANGE?

--> Display at 01:16:28:17
WHAT DRIVES THAT CHANGE?

--> Display at 01:16:30:06
AND ONE OF THE MAJOR KINDS
OF CHANGE IN A COMMUNITY

--> Display at 01:16:35:18
IS THE INCESSANT FLOW OF ENERGY

--> Display at 01:16:38:15
FROM ONE KIND OF ORGANISM
TO ANOTHER.

--> Display at 01:16:41:21
Narrator: COMMUNITIES
CAN BE BIG OR SMALL.

--> Display at 01:16:44:29
AND THEY EXIST IN NEARLY
EVERY IMAGINABLE ENVIRONMENT.

--> Display at 01:16:49:08
IN THIS ENORMOUS AQUARIUM,
THE MEMBERS OF THE COMMUNITY

--> Display at 01:16:52:11
ARE CARED FOR AND STUDIED
BY TEAMS OF BIOLOGISTS.

--> Display at 01:16:56:24
THEIR INTERACTIONS
ARE MONITORED,

--> Display at 01:16:59:03
AND SO ARE THEIR DIETS.

--> Display at 01:17:02:08
IN THIS COMMUNITY,
THE ANIMALS ARE EVEN HAND-FED

--> Display at 01:17:04:28
TO MAKE SURE THEY GET
THE ENERGY THEY NEED.

--> Display at 01:17:08:07
BUT IN THE REAL WORLD,
WHERE DOES THE ENERGY COME FROM?

--> Display at 01:17:11:24
AND WHY DOESN'T IT EVER RUN OUT?

--> Display at 01:17:15:26
IN NATURAL COMMUNITIES,
ONE WAY THAT ENERGY IS ACQUIRED

--> Display at 01:17:20:20
IS WHEN ONE ORGANISM
EATS ANOTHER.

--> Display at 01:17:24:06
THINK OF A SHARK

--> Display at 01:17:25:22
EATING A FISH.

--> Display at 01:17:27:17
THE CHEMICAL ENERGY
STORED IN THE FISH'S BODY

--> Display at 01:17:30:05
BECOMES FOOD THAT PROVIDES
THE SHARK WITH ENERGY.

--> Display at 01:17:33:29
SOME OF THE ENERGY STORED
IN THE FISH'S TISSUES

--> Display at 01:17:36:21
IS TRANSFERRED TO THE SHARK.

--> Display at 01:17:39:18
--> Erase at 01:17:42:15
BUT WHERE DID THE ENERGY
IN THE FISH COME FROM?

--> Display at 01:17:44:20
IT'S EASY TO IMAGINE THE FISH EATING AN EVEN SMALLER FISH,

--> Display at 01:17:48:25
AND THAT FISH
EATING SOMETHING ELSE,

--> Display at 01:17:51:08
AND SO ON.

--> Display at 01:17:52:26
BUT HOW FAR DOES IT EXTEND?

--> Display at 01:17:55:13
WHERE DOES THE FOOD CHAIN BEGIN?

--> Display at 01:17:58:02
THERE ARE ONLY TWO POSSIBLE WAYS TO RESOLVE THIS PROBLEM.

--> Display at 01:18:02:18
EITHER THE FOOD CHAIN
IS A CLOSED SYSTEM,

--> Display at 01:18:05:21
WITH THE SAME LIMITED SUPPLY
OF ENERGY

--> Display at 01:18:08:00
ENDLESSLY CYCLING
AMONG LIVING THINGS,

--> Display at 01:18:10:09
OR IT'S AN OPEN SYSTEM,
WHERE NEW ENERGY,

--> Display at 01:18:14:22
IN THE FORM OF FOOD, CONTINUALLY ENTERS THE COMMUNITY.

--> Display at 01:18:19:20
HOW CAN WE TELL WHICH EXPLANATION FITS THE FACTS?

--> Display at 01:18:23:24
IF YOU'VE EVER KEPT AN AQUARIUM,

--> Display at 01:18:27:28
YOU KNOW THAT YOU
MUST REGULARLY ADD FOOD

--> Display at 01:18:31:00
IN ORDER TO KEEP
THE COMMUNITY HEALTHY

--> Display at 01:18:32:27
AND THRIVING.

--> Display at 01:18:34:11
THE FACT THAT THE AQUARIUM

--> Display at 01:18:35:21
IS NOT SELF-SUSTAINING

--> Display at 01:18:37:13
IMPLIES THAT IT IS SOMEHOW INCOMPLETE.

--> Display at 01:18:40:23
AND IF YOU'RE NOT VIGILANT,
YOU WILL SEE

--> Display at 01:18:44:06
THAT WITHOUT THAT STEADY SUPPLY OF ENERGY IN THE FORM OF FOOD,

--> Display at 01:18:47:07
THE FISH WILL DIE.

--> Display at 01:18:50:16
WHAT DOES THAT IMPLY
FOR OUR WORLD?

--> Display at 01:18:52:23
--> Erase at 01:18:56:15
ARE WE, TOO, BEING
CONTINUALLY FED FROM ABOVE?

--> Display at 01:18:59:12
THE FACT IS, WE ARE.

--> Display at 01:19:02:24
THE MAJORITY
OF THE EARTH'S ENERGY

--> Display at 01:19:04:29
ARRIVES IN THE FORM
OF SUNLIGHT.

--> Display at 01:19:07:29
WHAT IS THE PROCESS
THAT TRANSFORMS SOMETHING

--> Display at 01:19:10:23
AS INTANGIBLE AS LIGHT

--> Display at 01:19:12:14
INTO A MEAL?

--> Display at 01:19:15:25
I'M GOING TO GIVE YOU
THIS WORD.

--> Display at 01:19:19:02
ENERGY.

--> Display at 01:19:20:27
WELL, IT'S BASICALLY HOW
THINGS SURVIVE AND MOVE.

--> Display at 01:19:26:01
THEY GET ENERGY.

--> Display at 01:19:27:08
BASICALLY
FUEL FOR BODIES.

--> Display at 01:19:29:15
LET'S SAY THE CHAMELEON
ATE ONE OF THE CRICKETS.

--> Display at 01:19:31:28
HE WOULD GET THE ENERGY
FROM THE CRICKET,

--> Display at 01:19:33:27
THAT THE CRICKET SUSTAINED
FROM ONE OF THE PLANTS,

--> Display at 01:19:36:06
THAT THE PLANT
SUSTAINED FROM THE SUN.

--> Display at 01:19:38:08
Zook: P.J. AND MICHAEL
ARE THINKING

--> Display at 01:19:39:23
ABOUT ENERGY IN LIVING SYSTEMS,

--> Display at 01:19:41:17
RELATING IT TO FOOD
AND TRACING ITS SOURCE

--> Display at 01:19:43:22
BACK TO THE SUN.

--> Display at 01:19:45:21
THEY MAY HAVE STUDIED
THE SUBJECT IN SCHOOL.

--> Display at 01:19:48:15
NEXT, WE ASKED THEM
HOW PLANTS ACQUIRE ENERGY.

--> Display at 01:19:52:28
FROM HEAT AND LIGHT.
THEY PHOTOSYNTHESIZE.

--> Display at 01:19:56:13
AND THEN THEY TURN
LIGHT AND HEAT INTO FOOD.

--> Display at 01:19:59:27
AND THAT'S HOW
THEY GET THEIR ENERGY.

--> Display at 01:20:01:23
I'M REALLY FASCINATED
BY THIS --

--> Display at 01:20:05:19
LIGHT PLUS HEAT IS THE ENERGY THAT THE PLANTS USE.

--> Display at 01:20:10:05
DO THEY NEED ANYTHING ELSE
TO MAKE THEIR FOOD?

--> Display at 01:20:12:20
YEAH, PROBABLY.
P.J.: WATER.

--> Display at 01:20:14:27
WATER.

--> Display at 01:20:16:25
Michael: THAT WOULD HELP.
AND AIR.

--> Display at 01:20:19:27
Michael: CARBON DIOXIDE,
NOT AIR.

--> Display at 01:20:22:01
WELL, AIR TECHNICALLY
IS CARBON DIOXIDE.

--> Display at 01:20:24:00
Abrams:
WE'LL PUT THAT UP THERE,

--> Display at 01:20:25:19
SAYING THAT IT'S
CARBON DIOXIDE.

--> Display at 01:20:29:21
P.J.: AND THAT'S HOW
THEY GET THEIR FOOD.

--> Display at 01:20:31:06
Michael: THAT'S HOW THEY MAKE --
WATER PLUS LIGHT,

--> Display at 01:20:33:08
PLUS HEAT, PLUS AIR EQUALS
FOOD.

--> Display at 01:20:37:07
--> Erase at 01:20:38:26
P.J.: YEAH.

--> Display at 01:20:40:16
P.J. AND MICHAEL ARE VERY CLOSE

--> Display at 01:20:43:18
TO PUTTING SOME KEY PIECES
OF THE PUZZLE TOGETHER.

--> Display at 01:20:46:12
THEY KNOW THAT CARBON DIOXIDE

IS IMPORTANT TO PLANTS.

--> Display at 01:20:50:03
BUT THEY SEEM TO INFER

--> Display at 01:20:52:04
THAT MOST OF THE AIR
IS MADE OF CARBON DIOXIDE.

--> Display at 01:20:54:28
IT ISN'T.

--> Display at 01:20:56:25
CARBON DIOXIDE MAKES UP LESS THAN 1% OF OUR ATMOSPHERE.

--> Display at 01:21:01:28
IT IS ESSENTIAL TO PLANTS, HOWEVER.

--> Display at 01:21:04:08
SO HOW DO PLANTS ACQUIRE
THE ENERGY REQUIRED FOR LIFE?

--> Display at 01:21:08:20
EXCEPT FOR A FEW UNUSUAL CASES,

--> Display at 01:21:12:15
PLANTS DON'T EAT,
IN THE SAME WAY THAT ANIMALS DO.

--> Display at 01:21:15:18
SO HOW DO THEY DO IT?

--> Display at 01:21:17:15
--> Erase at 01:21:20:20
WE PUT THESE QUESTIONS
TO DR. AARON ELLISON.

--> Display at 01:21:32:28
I'M DR. ELLISON,

--> Display at 01:21:34:26
AND I WORK AT THE HARVARD FOREST IN MASSACHUSETTS,

--> Display at 01:21:38:01
AND THIS IS
THE RESEARCH GREENHOUSE

--> Display at 01:21:39:11
THAT I USE FOR MY EXPERIMENTS.

--> Display at 01:21:42:01
SO HOW DO WE KNOW
THAT PLANTS PHOTOSYNTHESIZE?

--> Display at 01:21:45:02
WHAT WE KNOW ABOUT PHOTOSYNTHESIS

--> Display at 01:21:47:03
IS THAT PHOTOSYNTHESIS
IS ESSENTIALLY

--> Display at 01:21:49:08
THE PLANT TAKING CARBON DIOXIDE OUT OF THE ATMOSPHERE,

--> Display at 01:21:53:08
COMBINING IT WITH LIGHT ENERGY FROM THE SUN,

--> Display at 01:21:56:09
AND TURNING THAT INTO SUGARS AND STARCHES THAT THE PLANT STORES

--> Display at 01:22:00:14
FOR FUTURE ENERGY
FOR MAINTAINING ITSELF.

--> Display at 01:22:03:10
SO ONE WAY THAT SCIENTISTS
GO ABOUT MEASURING

--> Display at 01:22:07:23
AND UNDERSTANDING
HOW PHOTOSYNTHESIS HAPPENS

--> Display at 01:22:10:06
IS TO ACTUALLY WATCH A PLANT TAKE CARBON DIOXIDE

--> Display at 01:22:13:08
DIRECTLY OUT OF THE ATMOSPHERE.

--> Display at 01:22:15:06
--> Erase at 01:22:17:15
SO WE CAN DEMONSTRATE THAT HERE.

--> Display at 01:22:21:04
SO WE TAKE ONE OF THE LEAVES
OF THIS PITCHER PLANT,

--> Display at 01:22:24:17
AND WE CAN PUT IT
INSIDE THIS CHAMBER.

--> Display at 01:22:29:04
THERE'S LIGHT COMING IN
FROM ABOVE,

--> Display at 01:22:30:28
FROM SUNLIGHT, IT GOES THROUGH THE PLASTIC OF THE CHAMBER.

--> Display at 01:22:35:03
AND THE PLANT USES THAT SUNLIGHT

--> Display at 01:22:37:03
AND THE CARBON DIOXIDE
INSIDE THE CHAMBER

--> Display at 01:22:39:23
TO PHOTOSYNTHESIZE.

--> Display at 01:22:41:07
AND SO IF PHOTOSYNTHESIS
IS REALLY HAPPENING,

--> Display at 01:22:44:16
WE SHOULD BE ABLE TO WATCH

--> Display at 01:22:46:10
THE CARBON DIOXIDE
IN THE CHAMBER DISAPPEAR.

--> Display at 01:22:49:15
THIS IS A MACHINE FOR MEASURING PHOTOSYNTHESIS,

--> Display at 01:22:53:00
AND IT WORKS
ON A VERY SIMPLE PRINCIPLE.

--> Display at 01:22:55:09
YOU HAVE HOSES,
THEY COME OUT OF THE CHAMBER,

--> Display at 01:22:58:13
OUT OF THE BACK HERE,
AND THEY GO INTO THE MACHINE.

--> Display at 01:23:01:12
AND THEY'RE BASICALLY
TAKING SAMPLES

--> Display at 01:23:03:26
OF THE AIR INSIDE THE CHAMBER.

--> Display at 01:23:05:24
AND THEY RUN IT
THROUGH AN ANALYZER

--> Display at 01:23:09:01
IN THE GRAY BOX,
AND THE ANALYZER MEASURES

--> Display at 01:23:11:20

--> Erase at 01:23:14:20

THE AMOUNT OF CARBON DIOXIDE THAT'S IN THE CHAMBER.

--> Display at 01:23:17:00
SO WE PUT THE PLANT
INTO THE CHAMBER,

--> Display at 01:23:20:19
TURN ON THE FANS TO CIRCULATE THE AIR,

--> Display at 01:23:25:12
AND WE CLOSE THE LEAF

INTO THE CHAMBER.

--> Display at 01:23:28:05
AND THEN WE WATCH
AS IT TAKES SAMPLES

--> Display at 01:23:30:23
OF THE AIR EVERY SECOND,
WE CAN WATCH

--> Display at 01:23:33:13
THE AMOUNT OF CARBON DIOXIDE

--> Display at 01:23:35:00
IN THE CHAMBER

--> Display at 01:23:36:10
--> Erase at 01:23:37:25
SLOWLY GOING DOWN.

--> Display at 01:23:41:26
Narrator: EXPRESSED
AS AN EQUATION,

--> Display at 01:23:44:05
THE CHEMICAL REACTION
THAT ALLOWS PLANTS

--> Display at 01:23:46:23
TO HARNESS LIGHT ENERGY
LOOKS LIKE THIS.

--> Display at 01:23:50:19
PLANTS USE LIGHT ENERGY

--> Display at 01:23:52:13
TO CONVERT CARBON DIOXIDE
AND WATER

--> Display at 01:23:54:26
INTO SUGARS,

--> Display at 01:23:56:12
WITH OXYGEN
AS A BYPRODUCT OF THE REACTION.

--> Display at 01:24:01:04
DR. ELLISON'S DEMONSTRATION SHOWS

--> Display at 01:24:04:05
THAT WHEN A PLANT
IS EXPOSED TO SUNLIGHT,

--> Display at 01:24:05:29
THE AMOUNT OF CARBON DIOXIDE
IN THE CHAMBER DECREASES,

--> Display at 01:24:09:20
AS SUGAR IS PRODUCED.

--> Display at 01:24:11:15
THE SUGAR PRODUCED CAN THEN BE CONVERTED INTO A FORM OF ENERGY

--> Display at 01:24:16:12
CELLS CAN USE
IN ANOTHER PROCESS,

--> Display at 01:24:19:04
CALLED CELL RESPIRATION,

--> Display at 01:24:21:04
WHICH CAN ALSO BE DEMONSTRATED BY EXPERIMENT.

--> Display at 01:24:24:05
BUT IF WE PUT THE PLANT
INTO THE DARK,

--> Display at 01:24:26:22
SO THAT IT WAS NOT ABLE
TO PHOTOSYNTHESIZE,

--> Display at 01:24:29:17
WHICH WE CAN DO
IN THE GREENHOUSE

--> Display at 01:24:31:19
--> Erase at 01:24:33:23
BY PUTTING THIS BLACK COVER
OVER IT...

--> Display at 01:24:37:11
NOW THE PLANT IS NO LONGER ABLE TO GET ANY LIGHT

--> Display at 01:24:40:17
FOR PHOTOSYNTHESIS,
BUT IT STILL

--> Display at 01:24:42:20
IS USING ITS CHEMICAL ENERGY
FOR METABOLISM,

--> Display at 01:24:45:12
SO IT'S STILL RESPIRING.

--> Display at 01:24:47:05
NOW THE CARBON DIOXIDE
IN THE CHAMBER IS GOING UP

--> Display at 01:24:50:13
AS THE RESPIRATION

--> Display at 01:24:51:25
FROM THE PLANT GENERATES

--> Display at 01:24:53:18
CARBON DIOXIDE, BUT IT'S NOT

--> Display at 01:24:54:29
TAKING ANY MORE CARBON DIOXIDE

--> Display at 01:24:56:12
OUT OF THE ATMOSPHERE
THROUGH PHOTOSYNTHESIS.

--> Display at 01:24:59:26
THIS SWITCH FROM PHOTOSYNTHESIS TO RESPIRATION

--> Display at 01:25:02:23
HAPPENS VERY QUICKLY -- IT HAPPENS IN A MATTER OF SECONDS.

--> Display at 01:25:06:07
SO IF YOU'RE OUT IN THE FOREST AND A CLOUD GOES OVERHEAD,

--> Display at 01:25:10:05
THE PLANTS SLOW DOWN
THEIR PHOTOSYNTHESIS,

--> Display at 01:25:13:04
BUT THEY KEEP ON RESPIRING,
BECAUSE THEY NEED

--> Display at 01:25:15:29
TO BE RESPIRING,
JUST TO LIVE.

--> Display at 01:25:18:01
--> Erase at 01:25:21:16
IF A PLANT STOPS RESPIRING,
A PLANT DIES.

--> Display at 01:25:23:15
Narrator: EXPRESSED
AS AN EQUATION,

--> Display at 01:25:25:17
THE CHEMICAL REACTION

--> Display at 01:25:26:27
THAT HARNESSSES THE ENERGY
IN SUGAR MOLECULES

--> Display at 01:25:29:16
LOOKS LIKE THIS.

--> Display at 01:25:31:08
SUGAR PLUS OXYGEN REACT CHEMICALLY

--> Display at 01:25:34:04
TO PRODUCE
CARBON DIOXIDE AND WATER.

--> Display at 01:25:37:05
AND ENERGY IS MADE AVAILABLE
IN THE PROCESS.

--> Display at 01:25:40:29
THE PLANT LEAF IS PRODUCING
CARBON DIOXIDE

--> Display at 01:25:43:28
AS ITS CELLS CONVERT THE SUGARS MADE IN PHOTOSYNTHESIS

--> Display at 01:25:47:19
TO USABLE ENERGY.

--> Display at 01:25:49:27
MOST PLANTS AND ANIMALS
MUST RESPIRE

--> Display at 01:25:54:02
--> Erase at 01:25:57:12
TO MAKE ENERGY AVAILABLE
FOR CELL PROCESSES.

--> Display at 01:26:00:25
SO ALL THE PLANTS HERE,

--> Display at 01:26:02:17
LIKE VIRTUALLY ALL OTHER PLANTS IN THE WORLD,

--> Display at 01:26:05:28
TAKE THE ENERGY THEY GET
FROM THE SUN AND TURN IT

--> Display at 01:26:09:21
INTO ENERGY
THAT THE PLANTS CAN USE.

--> Display at 01:26:12:23
SO WHAT DO THEY USE
THIS ENERGY FOR?

--> Display at 01:26:14:11
WELL, THEY USE IT FOR PRODUCING PARTS OF THE PLANT,

--> Display at 01:26:17:25
SUCH AS LEAVES AND FLOWERS
AND ROOTS.

--> Display at 01:26:20:14
THEY USE IT
FOR MAINTENANCE AND GROWTH,

--> Display at 01:26:22:27
SO THEY USE IT TO PRODUCE
THE NECTAR THAT THE BEES USE,

--> Display at 01:26:28:19

IN ORDER TO BE ATTRACTED
TO THE PLANT.

--> Display at 01:26:30:14
THE PLANT MAKES NECTAR
AROUND THE EDGE OF THE MOUTH,

--> Display at 01:26:35:28
IN ORDER TO ATTRACT THE INSECTS TO COME INTO THE PLANT.

--> Display at 01:26:40:12
SO THE ENERGY THAT THE PLANTS GET FROM THE SUN

--> Display at 01:26:43:25
THAT THEY CONVERT INTO CHEMICAL ENERGY IN THE FORM OF SUGAR,

--> Display at 01:26:48:03
THEY STORE IN THEIR ROOTS

--> Display at 01:26:50:00
AND RHIZOMES,
BUT THAT CHEMICAL ENERGY,

--> Display at 01:26:52:03
ONCE IT'S CONVERTED
FROM SUNLIGHT,

--> Display at 01:26:53:29
--> Erase at 01:26:57:12
IS THE SAME ENERGY AS IT MOVES THROUGH THE FOOD CHAIN.

--> Display at 01:26:59:24
SO I STUDY COMMUNITIES,
AND THE COMMUNITY

--> Display at 01:27:03:00
THAT I STUDY IS NOT
A REALLY BIG COMMUNITY,

--> Display at 01:27:05:21
LIKE A FOREST COMMUNITY
OR A BOG COMMUNITY,

--> Display at 01:27:09:23
BUT I STUDY THE COMMUNITIES
THAT LIVE IN THE WATER

--> Display at 01:27:12:26
RIGHT INSIDE OF THESE PITCHERS.

--> Display at 01:27:14:23
THESE ARE REALLY SMALL COMMUNITIES,

--> Display at 01:27:17:03
MADE UP OF BACTERIA AND PROTOZOA AND ROTIFERS AND LARVAE

--> Display at 01:27:21:25

OF MOSQUITOES AND MIDGES
AND FLIES.

--> Display at 01:27:23:15
AND THEY ALL INTERACT

--> Display at 01:27:25:08
INSIDE OF EACH INDIVIDUAL PITCHER, TO MAKE A NICE

--> Display at 01:27:28:20
COMMUNITY THAT WE CAN STUDY
IN THE GREENHOUSE

--> Display at 01:27:32:04
OR IN THE FIELD -- THESE ARE
A NICE, SIMPLE COMMUNITY

--> Display at 01:27:34:26
TO DO EXPERIMENTS WITH.

--> Display at 01:27:37:21
PLANTS AND OTHER PRODUCERS MAKE THEIR OWN FOOD

--> Display at 01:27:41:04
USING ENERGY FROM SUNLIGHT.

--> Display at 01:27:43:01
CARBON DIOXIDE AND WATER ARE ALSO IMPORTANT INGREDIENTS

--> Display at 01:27:46:29
OF THE SUGARS THEY PRODUCE.

--> Display at 01:27:48:16
ALL OF OUR STUDENTS RECOGNIZED

--> Display at 01:27:50:24
THE SUN'S IMPORTANT ROLE
TO LIFE.

--> Display at 01:27:53:15
BUT NONE OF THE CHILDREN IDENTIFIED IT

--> Display at 01:27:55:24
AS THE SOLE SOURCE
OF ENERGY FOR PLANTS.

--> Display at 01:27:58:21
IT'S A POWERFUL IDEA THAT CAN BE DIFFICULT TO APPRECIATE,

--> Display at 01:28:02:16
ESPECIALLY BECAUSE
IT IS SO DIFFERENT

--> Display at 01:28:04:13
FROM OUR OWN EXPERIENCE
WITH ACQUIRING ENERGY.

--> Display at 01:28:06:21
AND YET WE ARE DEPENDENT
UPON THEM.

--> Display at 01:28:09:26
THE PRODUCERS ARE THE FIRST LINK IN THE FOOD CHAIN.

--> Display at 01:28:12:18
WITHOUT THEM, THE EARTH'S ENERGY IS UNAVAILABLE

--> Display at 01:28:15:04
TO NEARLY ALL LIVING THINGS.

--> Display at 01:28:17:14
AND I SAY NEARLY ALL, BECAUSE THERE ARE EXCEPTIONAL PRODUCERS,

--> Display at 01:28:20:28
LIKE THE CHEMOSYNTHETIC
BACTERIA

--> Display at 01:28:22:22
WE TALKED ABOUT
IN AN EARLIER SESSION.

--> Display at 01:28:25:22
THESE ORGANISMS
ACQUIRE ENERGY

--> Display at 01:28:27:15
FROM CHEMICALS RELEASED
IN OCEAN VENTS.

--> Display at 01:28:29:20
THE ENERGY THEY ACQUIRE
CAN THEN BE PASSED

--> Display at 01:28:33:05
TO OTHER ORGANISMS IN THE FOOD CHAIN IN THE USUAL WAYS.

--> Display at 01:28:37:17
WELL, WHAT ABOUT THE NEXT LINK
IN THE CHAIN --

--> Display at 01:28:39:16
THE CONSUMER ORGANISMS?

--> Display at 01:28:41:05
WHERE DO THEY
GET THEIR ENERGY?

--> Display at 01:28:43:16
WE PAID A VISIT
TO DR. MARIANNE FARRINGTON

--> Display at 01:28:45:27
TO SEE HOW CONSUMERS
IN AQUATIC ENVIRONMENTS

--> Display at 01:28:48:18

--> Erase at 01:28:51:18

ACQUIRE THE ENERGY
THAT THEY NEED.

--> Display at 01:29:03:18

WHEN YOU'RE TALKING ABOUT
THE COMMUNITIES

--> Display at 01:29:05:12

THAT YOU FIND IN THE OCEAN,
THERE'S REALLY LITTLE DIFFERENCE

--> Display at 01:29:07:27

BETWEEN WHAT YOU FIND IN THE OCEAN AND WHAT YOU FIND ON LAND.

--> Display at 01:29:10:14

YOU'RE GOING TO HAVE ANIMALS THAT EAT OTHER ANIMALS,

--> Display at 01:29:12:20

YOU'RE GOING TO HAVE ANIMALS THAT EAT PLANTS.

--> Display at 01:29:15:02

YOU'RE GOING TO FIND
ANIMALS THAT EAT BOTH.

--> Display at 01:29:17:11

THE TYPES OF CONSUMERS
THAT WE HAVE IN THIS TANK,

--> Display at 01:29:20:10

WE HAVE A LOT OF PREDATORS
IN THIS TANK.

--> Display at 01:29:22:05

BUT THERE ISN'T PREDATION

--> Display at 01:29:23:18

GOING ON -- AT LEAST,
VERY, VERY LITTLE PREDATION

--> Display at 01:29:26:08

GOING ON IN OUR TANK.

--> Display at 01:29:27:18

AND THAT'S BECAUSE
WE FEED THEM

--> Display at 01:29:29:09

ON A REGULAR SCHEDULE,
AND WE FEED THEM, HOPEFULLY,

--> Display at 01:29:31:21

TO SATIETY, SO THAT
THEY DON'T FEEL THE NEED

--> Display at 01:29:33:29
--> Erase at 01:29:35:28
TO GO OUT AND SHOP
FOR THEMSELVES.

--> Display at 01:29:40:25
EVERYTHING, FIRST OFF,
IS RESTAURANT-QUALITY.

--> Display at 01:29:43:12
SO WHEN YOU SEE THE SHRIMP GOING

--> Display at 01:29:44:24
INTO THE GIANT OCEAN TANK,
THAT'S A SHRIMP COCKTAIL

--> Display at 01:29:47:01
--> Erase at 01:29:50:28
THAT YOU COULD GET AT A VERY NICE RESTAURANT IN BOSTON.

--> Display at 01:29:54:17
THEY DO ACTUALLY HAND-FEED
SOME OF THOSE ANIMALS.

--> Display at 01:29:56:27
--> Erase at 01:30:00:24
THEY GO DOWN, THEY HAVE
ALL THE FOOD IN A BAG...

--> Display at 01:30:03:29
AND THEY HAVE TO BE VERY,
VERY PARTICULAR,

--> Display at 01:30:05:17
BECAUSE IF YOU LOOK
AT THE ANIMALS

--> Display at 01:30:07:00
AND YOU LOOK AT
THEIR MOUTHS,

--> Display at 01:30:08:07
SOME MOUTHS
ARE REALLY, REALLY TINY

--> Display at 01:30:09:20
AND SOME MOUTHS
ARE REALLY LARGE.

--> Display at 01:30:11:04
SO THEY HAVE TO TAILOR
THE TYPE OF FOOD

--> Display at 01:30:12:28
THAT THEY MAKE
FOR EACH INDIVIDUAL ANIMAL.

--> Display at 01:30:14:26
Woman: WELL, THIS WAS THE FIRST

--> Display at 01:30:17:17
FEEDING OF THE DAY, AND IT TENDS TO BE THE MOST IMPORTANT.

--> Display at 01:30:20:23
WHAT WE DO INITIALLY
IS ADDRESS ALL THE PREDATORS.

--> Display at 01:30:24:01
AND ONCE THE PREDATORS ARE FED,

--> Display at 01:30:25:22
THEN WE START DOING
A LOT OF BROADCAST FEEDINGS

--> Display at 01:30:28:03
AND TARGET FEEDINGS.

--> Display at 01:30:29:23
BECAUSE A LOT OF ANIMALS
ARE VERY TERRITORIAL,

--> Display at 01:30:31:18
AND THEY WON'T LEAVE THEIR AREA.

--> Display at 01:30:33:00
AND THEY EXPECT US TO COME
RIGHT TO THEM WITH THEIR FOOD.

--> Display at 01:30:35:10
I DON'T THINK WE CAME UP
WITH A BAG OR A BUCKET

--> Display at 01:30:38:11
THAT HAD A PIECE OF FOOD IN IT,

--> Display at 01:30:39:21
SO EVERYBODY ATE THIS MORNING.

--> Display at 01:30:41:19
AND THEY'LL ALL BE OFFERED FOOD AT LEAST THREE MORE TIMES TODAY.

--> Display at 01:30:45:13
AQUARIUMS ARE ARTIFICIAL COMMUNITIES.

--> Display at 01:30:47:29
THE ORGANISMS IN THIS TANK
HAVE THE SAME ENERGY NEEDS

--> Display at 01:30:51:05
AS CONSUMERS IN THE WILD.

--> Display at 01:30:52:22
THEY JUST RECEIVE IT
IN A DIFFERENT WAY --

--> Display at 01:30:55:03
BY HAND THREE TIMES A DAY.

--> Display at 01:30:57:02
BUT WHAT HAPPENS
IN NATURAL COMMUNITIES?

--> Display at 01:31:00:04
WHERE DO ANIMALS
GET THEIR ENERGY?

--> Display at 01:31:02:08
WE ASKED THE STUDENTS
IN THE STUDIO CLASSROOM

--> Display at 01:31:04:24
FOR THEIR IDEAS.

--> Display at 01:31:06:11
LET'S LISTEN TO THEIR THOUGHTS ABOUT ANIMALS

--> Display at 01:31:08:26
AND THE FOOD THEY EAT.

--> Display at 01:31:10:15
SO YOU HAVE THE SUN AND THE AIR AND THE WATER

--> Display at 01:31:15:02
GOING FROM THE PLANTS

--> Display at 01:31:17:08
TO THE MEALWORMS

--> Display at 01:31:18:19
TO THE CHAMELEON.

--> Display at 01:31:20:09
WHAT HAPPENS ONCE IT
GETS INTO THE CHAMELEON?

--> Display at 01:31:22:15
WHAT WOULD HAPPEN --
COULD WE GO ON?

--> Display at 01:31:25:02
SO WHAT WOULD HAPPEN
AFTER HERE?

--> Display at 01:31:26:20
YEAH, PROBABLY, IT CAN,
LIKE, THE CHAMELEON,

--> Display at 01:31:30:20
SOMETHING ELSE, LIKE A BIGGER ANIMAL THAN A CHAMELEON,

--> Display at 01:31:35:11

COULD EAT THE CHAMELEON,

--> Display at 01:31:37:14
AND THEN THE BIGGER
ANIMAL CAN EAT,

--> Display at 01:31:40:04
LIKE, THE CRICKETS
AND THE MEALWORMS

--> Display at 01:31:42:04
AND THE ISOPODS AND THE,
WHAT'S IT CALLED,

--> Display at 01:31:45:19
PLANTS, AND IT NEEDS
SUN AND AIR.

--> Display at 01:31:49:10
DOES IT EVER END?

--> Display at 01:31:51:02
Nirvana: NO, I DON'T
THINK IT EVER DOES.

--> Display at 01:31:54:03
Robert: NO,
SAME THING WITH ME.

--> Display at 01:31:55:19
Nirvana: EXCEPT, ONLY IF IT GETS TO, LIKE, THE BIGGEST ANIMAL.

--> Display at 01:31:59:11
THAT'S WHAT I WAS GOING TO ASK YOU, THAT'S A GOOD QUESTION.

--> Display at 01:32:01:16
Nirvana: YEAH, SO AFTER, LIKE,

--> Display at 01:32:02:26
THE BIGGEST ANIMAL, I DON'T THINK IT, LIKE,

--> Display at 01:32:05:12
GOES ANYWHERE FARTHER.

--> Display at 01:32:07:06
UNLESS, LIKE, PEOPLE
EAT THE BIGGEST ANIMAL.

--> Display at 01:32:10:02
WHICH IS, I DON'T
THINK WILL HAPPEN.

--> Display at 01:32:13:04
AND SO THEN, IF NO PEOPLE
EAT THE BIGGEST ANIMAL,

--> Display at 01:32:18:17

THEN IT WON'T GO ANYWHERE.

--> Display at 01:32:21:14
NIRVANA CORRECTLY UNDERSTANDS

--> Display at 01:32:23:23
THAT ENERGY FLOWS
IN ONE DIRECTION.

--> Display at 01:32:26:24
BUT FOOD CHAINS DON'T END
WITH THE BIGGEST ANIMALS,

--> Display at 01:32:30:06
AS SHE SUGGESTS.

--> Display at 01:32:31:17
BUT SHE TOUCHES
ON AN IMPORTANT IDEA.

--> Display at 01:32:34:20
JUST HOW MANY LEVELS OF CONSUMER ANIMALS CAN A COMMUNITY SUPPORT?

--> Display at 01:32:39:18

--> Erase at 01:32:44:00

TO FIND OUT, WE PUT THESE QUESTIONS TO DR. LES KAUFMAN.

--> Display at 01:32:54:21
IN THIS LAKE, THE BASE
OF THE FOOD PYRAMID WOULD BE

--> Display at 01:32:58:11
EITHER THE PHYTOPLANKTON
GROWING IN THE WATER,

--> Display at 01:33:01:23
OR THE LARGER PLANTS
ON THE BOTTOM OF THE LAKE.

--> Display at 01:33:05:01
ALL OF THESE ARE
THE PRIMARY PRODUCERS.

--> Display at 01:33:07:29
THEY'RE GRAZED UPON BY SNAILS AND BY FISHES

--> Display at 01:33:13:05
AND BY THE LARVAL FORMS
OF INSECTS, LIKE MAYFLIES.

--> Display at 01:33:17:07
THEY, IN TURN,
ARE EATEN BY FISH,

--> Display at 01:33:19:10
LIKE THE MINNOWS IN THIS POND.

--> Display at 01:33:21:09
AH, YES!

--> Display at 01:33:25:27
THESE ARE MINNOWS,

--> Display at 01:33:27:17
THE MINNOWS ARE FOOD FOR BIGGER FISH, YOU KNOW HOW IT GOES.

--> Display at 01:33:30:27
AND THEN THE BIGGEST FISH
IN THE POND

--> Display at 01:33:33:03
ARE PREYED UPON BY PEOPLE
AND BY OSPREY, FISH HAWKS.

--> Display at 01:33:39:13
AND THE INTERESTING THING
IS THAT THE MAXIMUM NUMBER

--> Display at 01:33:42:21
OF LEVELS THAT YOU SEE
IS USUALLY VERY SMALL,

--> Display at 01:33:45:17
GENERALLY FIVE, AT MOST SIX LEVELS IN A FOOD CHAIN.

--> Display at 01:33:50:28
THE REASON THIS HAS TO BE IS THAT YOU LOSE SO MUCH ENERGY

--> Display at 01:33:55:11
GOING FROM ONE LEVEL
OF THE FOOD CHAIN TO THE NEXT,

--> Display at 01:33:58:25
THAT BY THE TIME YOU GET SIX LEVELS UP,

--> Display at 01:34:01:13
IT WOULD BE VERY, VERY DIFFICULT TO SUPPORT AN ANIMAL

--> Display at 01:34:04:21
THAT ONLY EXISTED AT THAT LEVEL IN THE FOOD CHAIN.

--> Display at 01:34:08:26
Narrator: BIOLOGISTS
USE A PYRAMID

--> Display at 01:34:12:00
TO REPRESENT THE AMOUNT OF ENERGY AVAILABLE TO ORGANISMS

--> Display at 01:34:15:06
AT DIFFERENT LEVELS
OF A FOOD CHAIN.

--> Display at 01:34:17:13
A SIMPLIFIED PYRAMID

FOR A POND COMMUNITY

--> Display at 01:34:21:02
MIGHT LOOK LIKE THIS.

--> Display at 01:34:23:12
PLANTS, PHYTOPLANKTON,
AND OTHER PRODUCERS

--> Display at 01:34:26:28
ARE AT THE BOTTOM
OF THE PYRAMID.

--> Display at 01:34:28:27
THESE ORGANISMS
CAPTURE THE SUN'S ENERGY

--> Display at 01:34:32:09
AND USE MOST OF IT
KEEPING THEMSELVES ALIVE.

--> Display at 01:34:35:29
THEY ALSO STORE SOME
OF THE ENERGY THEY CAPTURE

--> Display at 01:34:38:27
IN THEIR TISSUES.

--> Display at 01:34:40:20
THIS STORED ENERGY IS AVAILABLE TO ORGANISMS

--> Display at 01:34:43:17
AT THE SECOND LEVEL
OF THE PYRAMID --

--> Display at 01:34:45:29
THE SNAILS, FISHES, MAYFLIES, AND OTHER PRIMARY CONSUMERS.

--> Display at 01:34:52:13
AND SO IT GOES,
AT EACH STEP OF THE PYRAMID.

--> Display at 01:34:55:21
ORGANISMS USE ENERGY
AND CONVERT IT TO HEAT --

--> Display at 01:34:59:11
LEAVING LESS TO THE ORGANISMS
IN THE LEVELS ABOVE.

--> Display at 01:35:03:18
AS A RESULT, ONLY A FRACTION

--> Display at 01:35:05:17
OF THE ENERGY INITIALLY CAPTURED BY THE PRODUCERS

--> Display at 01:35:09:01

IS AVAILABLE
TO THE PERCH AND BASS

--> Display at 01:35:11:10
AT THE FOURTH LEVEL
OF THE PYRAMID.

--> Display at 01:35:13:20
AND EVEN LESS IS AVAILABLE

--> Display at 01:35:15:28
TO THE FIFTH-LEVEL PREDATORS THAT EAT THEM.

--> Display at 01:35:19:23
THERE IS NO SIXTH LEVEL
TO THIS PYRAMID.

--> Display at 01:35:22:06
THERE IS SIMPLY
NOT ENOUGH ENERGY

--> Display at 01:35:24:19
STORED IN TOP-LEVEL PREDATORS, LIKE OSPREY,

--> Display at 01:35:27:20
TO SUPPORT THE ENERGY DEMANDS
OF A POPULATION OF CARNIVORES

--> Display at 01:35:31:00
THAT FEEDS EXCLUSIVELY ON THEM.

--> Display at 01:35:33:00
AND SO THE FOOD CHAIN ENDS.

--> Display at 01:35:37:10
THE LENGTH OF A FOOD CHAIN
IS LIMITED

--> Display at 01:35:39:25
BY THE INEFFICIENCIES
OF ENERGY TRANSFER AND USE.

--> Display at 01:35:42:29
WITH EACH ENERGY TRANSACTION, HEAT ENERGY IS RELEASED.

--> Display at 01:35:46:16
BECAUSE HEAT
IS NOT A FORM

--> Display at 01:35:48:13
OF ENERGY THAT
LIVING THINGS CAN STORE,

--> Display at 01:35:51:02
THE HEAT ENERGY IS RADIATED
INTO THE ENVIRONMENT.

--> Display at 01:35:54:16
LET'S CHECK IN
WITH PAUL WILLIAMS,

--> Display at 01:35:56:20
OUR BOTTLE BIOLOGIST.

--> Display at 01:35:58:09
PERHAPS HIS EXPERIMENTAL COMMUNITIES CAN SHED LIGHT

--> Display at 01:36:01:15
--> Erase at 01:36:03:25
ON ENERGY FLOW
AND FOOD CHAINS.

--> Display at 01:36:18:18
TIME TO CHECK IN
WITH BOTTLE BIOLOGY.

--> Display at 01:36:21:02
I HOPE YOU'VE VISITED
THE WEBSITE

--> Display at 01:36:22:21
TO FOLLOW PROGRESS
WITH OUR SYSTEMS,

--> Display at 01:36:24:14
AND THAT YOU'VE FOUND PLENTY
OF ACTIVITIES TO DO THERE.

--> Display at 01:36:27:28
WE'VE NOW COME FULL CIRCLE

--> Display at 01:36:29:16
WITH THE BRASSICA AND BUTTERFLY SYSTEM.

--> Display at 01:36:32:03
IN A LITTLE OVER A MONTH,

--> Display at 01:36:33:13
WE'VE GONE FROM EGG TO EGG
WITH THE BUTTERFLY

--> Display at 01:36:35:12
AND SEED TO SEED
WITH THE BRASSICA.

--> Display at 01:36:38:09
NEW LIFE CYCLES ARE BEGINNING,
AS THE BUTTERFLIES LAY EGGS

--> Display at 01:36:41:05
AND BRASSICA SEEDS
DEVELOP IN PODS.

--> Display at 01:36:44:10

TAKE A LOOK AT WHAT'S HAPPENED WITH THE FIELD POPULATION.

--> Display at 01:36:47:26
HAVE SOME INDIVIDUAL PLANTS
SURVIVED BETTER THAN OTHERS?

--> Display at 01:36:51:11
HOW MIGHT THIS POPULATION
OF BRASSICAS

--> Display at 01:36:53:24
BE CHANGED OVER TIME
BY LARVAL FEEDING?

--> Display at 01:36:57:00
OUR HUNT FOR MICROBES
IN THE TERRAQUA AND ECOCOLUMNS

--> Display at 01:37:00:10
WAS VERY SUCCESSFUL.

--> Display at 01:37:01:25
THE PLATES HAVE COLONIES
OF FUNGI AND BACTERIA

--> Display at 01:37:04:10
GROWING ON THEM.

--> Display at 01:37:05:24
THESE MICROBES
ARE THE DECOMPOSERS.

--> Display at 01:37:08:06
MICROBES ARE AT THE END
OF THE FOOD CHAIN

--> Display at 01:37:10:07
AND ARE THE VITAL LINK

--> Display at 01:37:11:17
FOR RECYCLING MATERIALS
IN ECOSYSTEMS.

--> Display at 01:37:14:24
THAT'S ALL FOR NOW.

--> Display at 01:37:16:19
--> Erase at 01:37:18:27
SEE YOU NEXT TIME.

--> Display at 01:37:24:00
THANKS, PAUL,
WE'RE LOOKING FORWARD TO IT.

--> Display at 01:37:27:01
PAUL HAS JUST INTRODUCED

--> Display at 01:37:28:22
THE FINAL TOPIC
IN TODAY'S PROGRAM --

--> Display at 01:37:31:15
DECOMPOSERS.

--> Display at 01:37:33:02
DECOMPOSERS ARE KEY PLAYERS IN THE MATERIALS MERRY-GO-ROUND,

--> Display at 01:37:36:18
AS HE MENTIONED.

--> Display at 01:37:38:07
BUT WHAT ROLE DO THEY PLAY
IN ENERGY FLOW?

--> Display at 01:37:41:08
WELL, LET'S RETURN
TO MELISSA MINNICK'S

--> Display at 01:37:43:01
5th-GRADE CLASS,
WHERE STUDENTS CONTINUE

--> Display at 01:37:45:10
TO EXPLORE THE EXPERIMENTAL COMMUNITIES

--> Display at 01:37:47:18
INSIDE
THEIR TERRARIUMS.

--> Display at 01:37:49:05
THEY'RE NEARING THE END
OF THE FOOD CHAIN,

--> Display at 01:37:52:01
AND THE UNEXPECTED
DEATH OF AN ANOLE,

--> Display at 01:37:54:08
A TYPE OF CHAMELEON,

--> Display at 01:37:55:28
IS LEADING TO
SOME LIVELY DISCUSSIONS

--> Display at 01:37:58:09
AROUND THE DECOMPOSERS.

--> Display at 01:37:59:23
SO LET'S TALK ABOUT,
AS A CLASS,

--> Display at 01:38:01:13
SOME OF THE THINGS
THAT YOU SAW HAPPENING

--> Display at 01:38:02:28
IN YOUR TERRARIUMS.

--> Display at 01:38:04:10
WHAT DID YOU SEE,
RACHEL?

--> Display at 01:38:05:25
WELL, WE SAW
THAT THE DEAD ANOLE

--> Display at 01:38:09:01
HAS GOTTEN BROWNER
AND SHRIVELED UP MORE.

--> Display at 01:38:12:27
Minnick: AND I THINK ONE
OF YOU SAID "SMUSHIER."

--> Display at 01:38:15:03
HOW CAN WE
EXPLAIN WHAT'S

--> Display at 01:38:16:18
HAPPENING TO THAT
DEAD ANOLE?

--> Display at 01:38:18:09
WHAT'S
HAPPENING THERE?

--> Display at 01:38:20:15
MOLLY?
WHAT'S HAPPENING?

--> Display at 01:38:23:14
THE MOLD OR BACTERIA

--> Display at 01:38:25:01
COULD BE SQUIRTING OUT
ITS DIGESTIVE FLUIDS.

--> Display at 01:38:28:11
AND THEN IT'S CAUSING IT
TO BECOME MUSHY.

--> Display at 01:38:30:25
--> Erase at 01:38:33:19
Minnick: WHY DOES THE MOLD
AND BACTERIA DO THAT?

--> Display at 01:38:36:11
JESSICA, WHY?

--> Display at 01:38:37:25
BECAUSE THEY DON'T

HAVE STOMACHS,

--> Display at 01:38:41:02
SO THEY CAN'T EAT IT,
OR IT WON'T GO ANYWHERE,

--> Display at 01:38:44:23
BECAUSE THEY CAN'T DIGEST IT
IN THEIR STOMACH, LIKE WE DO.

--> Display at 01:38:47:13
SO THEY HAVE
TO SQUIRT OUT THE JUICES

--> Display at 01:38:50:00
AND SOAK THEM UP
SO THEY CAN GET THE ENERGY.

--> Display at 01:38:52:28
Minnick:
OTHER IDEAS?

--> Display at 01:38:54:05
Minnick: THEN WE TALKED ABOUT IT AS A LARGE GROUP,

--> Display at 01:38:56:07
AND OF COURSE,
THE DEAD ANOLE CAME UP AGAIN,

--> Display at 01:38:58:02
WHICH WAS A PERFECT SEGUE
FOR US

--> Display at 01:39:01:09
TO GET INTO THE CONVERSATION ABOUT RAW MATERIALS,

--> Display at 01:39:03:15
AND WHAT PLANTS NEED TO GROW.

--> Display at 01:39:05:10
SO THAT WAS WHAT LED US
TO THE IDEA OF LIGHT,

--> Display at 01:39:08:23
AND INTRODUCING LIGHT
TO OUR COMMUNITY'S CHART

--> Display at 01:39:10:24
AS AN ESSENTIAL PART
OF PHOTOSYNTHESIS

--> Display at 01:39:13:04
AND AS THE PIECE THAT GIVES ENERGY TO PLANTS.

--> Display at 01:39:15:19
Minnick: YOU GUYS
ARE HAVING

--> Display at 01:39:17:11
SOME REALLY GOOD
SCIENTIFIC THOUGHTS.

--> Display at 01:39:19:16
BUT LET'S GO BACK
TO OUR CHART REAL QUICK.

--> Display at 01:39:21:14
LET'S TALK
ABOUT RAW MATERIALS AGAIN.

--> Display at 01:39:22:25
WE SAID BEFORE THAT RAW MATERIALS ARE GOING TO HELP --

--> Display at 01:39:26:04
YOU GUYS KEEP COMING BACK
TO THIS, THESE RAW MATERIALS,

--> Display at 01:39:28:12
WHAT'S LEFT OVER
FROM THAT ANOLE OR THAT FOX

--> Display at 01:39:30:22
BEING ALL SMUSHED UP,
LIKE YOU WERE SAYING,

--> Display at 01:39:33:01
IS GOING TO THEN
HELP UP THESE PLANTS.

--> Display at 01:39:36:11
WHAT ELSE DO PLANTS NEED
TO LIVE?

--> Display at 01:39:38:21
WHERE DOES THE PLANT
GET THE ENERGY FROM?

--> Display at 01:39:43:16
IT NEEDS WHAT, JOHN?

--> Display at 01:39:44:29
LIGHT?
IT NEEDS LIGHT, VERY GOOD.

--> Display at 01:39:47:07
WHY IS LIGHT SO IMPORTANT

--> Display at 01:39:49:15
TO A PLANT'S GROWTH,
DO YOU KNOW?

--> Display at 01:39:52:21
REMEMBER HOW WE SAY
ENERGY GOES

--> Display at 01:39:54:09
FROM HERE TO HERE
TO HERE TO HERE?

--> Display at 01:39:55:28
WHAT DOES LIGHT
HAVE TO DO WITH THIS?

--> Display at 01:39:59:00
Boy: WELL, SOMETIMES,
YOU CAN FIND --

--> Display at 01:40:00:23
WELL, YOU CAN'T FIND IT,
BUT THERE'S,

--> Display at 01:40:02:15
LIKE, ENERGY
IN LIGHT SOMETIMES?

--> Display at 01:40:03:29
YEAH!

--> Display at 01:40:05:09
SO LIGHT GIVES THE PLANT
THE ENERGY IT NEEDS TO GROW.

--> Display at 01:40:09:07
HOW ABOUT THAT?

--> Display at 01:40:10:17
THAT KIND OF
REMINDED ME OF, LIKE,

--> Display at 01:40:13:09
LIKE NUTRITION, SORT OF.

--> Display at 01:40:15:04
LIKE, ON THE BACK
OF A CEREAL BOX,

--> Display at 01:40:17:03
IT WILL HAVE, LIKE,
THE NUTRIENTS IT HAS

--> Display at 01:40:19:06
THAT WILL FEED YOU.

--> Display at 01:40:20:16
AND SO, LIKE SHE SAID,
FOR OTHER ANIMALS,

--> Display at 01:40:23:05
THEY GET THEIR NUTRIENTS FROM, LIKE, FRUIT AND STUFF.

--> Display at 01:40:26:12

MAYBE PLANTS HAVE, LIKE, WATER AND LIGHT AS THEIR NUTRIENTS.

--> Display at 01:40:33:11
WE SAW EARLIER
THAT FOOD CONTAINS

--> Display at 01:40:36:00
BOTH NUTRIENTS AND ENERGY.

--> Display at 01:40:38:06
AND THAT EACH MAKES
A DISTINCT CONTRIBUTION TO LIFE.

--> Display at 01:40:41:24
THE SUN DOES NOT PROVIDE NUTRIENTS,

--> Display at 01:40:44:11
AS THE STUDENT SUGGESTS.

--> Display at 01:40:46:02
IT PROVIDES ENERGY.

--> Display at 01:40:48:05
THE NUTRIENTS COME
FROM THE RAW MATERIALS.

--> Display at 01:40:51:03
THE DISTINCTION IS IMPORTANT, BUT OFTEN GOES UNRECOGNIZED.

--> Display at 01:40:55:22
THE DEAD ANOLE
DRAMATICALLY ILLUSTRATES

--> Display at 01:40:58:02
THE ROLE PLAYED
BY THE DECOMPOSERS.

--> Display at 01:41:00:08
THE STUDENTS
OBSERVED FIRST-HAND

--> Display at 01:41:02:20
THAT LIFE
DEPENDS ON DEATH.

--> Display at 01:41:05:01
DEAD ORGANISMS
ARE CONSUMED

--> Display at 01:41:07:09
BY OTHER CONSUMERS,
LIKE SCAVENGERS,

--> Display at 01:41:10:21
BUT ALSO
BY MICROORGANISMS

--> Display at 01:41:12:17
SUCH AS BACTERIA
AND MOLD.

--> Display at 01:41:15:04
TO FIND OUT WHAT
OUR STUDENTS ARE THINKING

--> Display at 01:41:17:12
ABOUT THE PROCESS
OF DECOMPOSITION,

--> Display at 01:41:19:10
WE ASKED THEM
TO SHARE THEIR IDEAS

--> Display at 01:41:21:18
ABOUT DEATH
AND ENERGY FLOW

--> Display at 01:41:23:12
WITHIN A COMMUNITY.

--> Display at 01:41:24:22
WE ASKED THEM,

--> Display at 01:41:26:03
WHERE DOES ENERGY GO
WHEN AN ORGANISM DIES?

--> Display at 01:41:30:03
Abrams: IS THERE ENERGY IN THAT THAT ANYTHING ELSE COULD USE?

--> Display at 01:41:33:03
Greg: NO.
NO.

--> Display at 01:41:34:13
Greg: YES, YES.
I DON'T KNOW.

--> Display at 01:41:37:15
Greg: ANIMALS EAT DEAD PLANTS AND DEAD ANIMALS,

--> Display at 01:41:39:05
LIKE VULTURES,
THEY EAT DEAD ANIMALS.

--> Display at 01:41:41:06
Maggy: YEAH,
THAT'S TRUE, THAT'S TRUE.

--> Display at 01:41:43:02
AND AS LONG AS IT'S NUTRIENTS --

--> Display at 01:41:44:20
'CAUSE THEY STILL HAVE THE FAT AND SKIN AND BLOOD ON THEM.

--> Display at 01:41:47:19
AND THAT WOULD BE
NUTRIENTS TO A VULTURE.

--> Display at 01:41:51:06
IF IT DIES RIGHT NOW,

--> Display at 01:41:52:29
AND IT JUST HAD ATE
AND THEN IT DIES,

--> Display at 01:41:56:04
IT STILL HAS ENERGY,

--> Display at 01:41:57:16
BUT AFTER A WHILE,
AFTER A COUPLE OF DAYS,

--> Display at 01:42:00:14
THE ENERGY WILL, LIKE, JUST --

--> Display at 01:42:02:13
NO, I THINK IT'LL STILL STAY.

--> Display at 01:42:04:11
BUT THEY JUST DON'T USE IT,

--> Display at 01:42:06:02
AND THEY DON'T NEED IT ANYMORE.

--> Display at 01:42:08:00
Abrams: WHY DO YOU THINK
IT'LL STILL STAY?

--> Display at 01:42:10:00
BECAUSE THEY'RE NOT DOING ANYTHING WITH IT,

--> Display at 01:42:12:16
AND YOU JUST NEED, LIKE, FOOD AND STUFF TO GET MORE ENERGY,

--> Display at 01:42:18:05
BUT IT'S JUST, THE ENERGY
IS STILL INSIDE THEM,

--> Display at 01:42:21:09
SO -- AND THEY'RE NOT USING IT, SO IT JUST STAYS THERE.

--> Display at 01:42:24:00
Zook: THE CHILDREN
SEEM TO AGREE

--> Display at 01:42:26:03
THAT ORGANISMS RETAIN ENERGY WHEN THEY DIE.

--> Display at 01:42:29:05
GREG AND MAGGY

DRAW THIS CONCLUSION

--> Display at 01:42:31:11
BY RECOGNIZING
THAT DEAD ORGANISMS

--> Display at 01:42:33:16
CAN BE A FOOD SOURCE
FOR OTHER ANIMALS.

--> Display at 01:42:35:29
NEXT, WE ASKED THEM
TO DESCRIBE

--> Display at 01:42:37:27
WHERE THE ENERGY
GOES FROM THERE.

--> Display at 01:42:39:28
Abrams: SO ONCE IT GOES INTO THESE LITTLE TINY PIECES,

--> Display at 01:42:42:10
DOES ALL THE ENERGY
GET SPLIT UP

--> Display at 01:42:43:25
INTO THE LITTLE
TINY PIECES?

--> Display at 01:42:45:05
Both: YEAH.

--> Display at 01:42:46:19
'CAUSE IT ONCE WAS ALL,
IT ONCE WAS ONE.

--> Display at 01:42:49:26
A BIG CLUMP
OF ENERGY.

--> Display at 01:42:51:06
AND THEN, NOW IT'S
BREAKING APART,

--> Display at 01:42:53:22
AND IT'S OTHER PIECES,

--> Display at 01:42:55:10
BUT IT STILL
HAS ITS ENERGY.

--> Display at 01:42:57:15
IT SPLITS IT UP.

--> Display at 01:42:58:27
UH-HUH.

--> Display at 01:43:00:23
Abrams: DOES IT, IS IT ALWAYS GOING TO KEEP THAT ENERGY?

--> Display at 01:43:03:02
DOES ANYTHING HAPPEN TO THAT ENERGY NOW THAT IT'S DEAD?

--> Display at 01:43:05:21
UH, NO.
NO.

--> Display at 01:43:07:05
I GUESS, 'CAUSE IT
DOESN'T GET MORE ENERGY.

--> Display at 01:43:08:21
YEAH, IT CAN'T
GET MORE ENERGY,

--> Display at 01:43:10:14
BECAUSE IT'S DEAD,
IT DOESN'T HAVE,

--> Display at 01:43:12:11
IT'S NOT GETTING
THE NUTRIENTS FROM THE TREE

--> Display at 01:43:14:21
THAT IT USED TO GET,
SO THAT'S WHY

--> Display at 01:43:16:18
IT STARTED
TO SHRIVEL UP.

--> Display at 01:43:18:21
BUT IF IT HAD, LIKE,
10 WHATEVERS OF ENERGY IN HERE,

--> Display at 01:43:22:19
IT WOULD ALWAYS HAVE
10 UNITS OF ENERGY?

--> Display at 01:43:25:24
SO EVEN IF IT
WAS IN THE SOIL,

--> Display at 01:43:27:10
THERE WOULD BE
10 OF IT IN THE SOIL?

--> Display at 01:43:29:09
YEAH, I GUESS ENERGY
IS LIKE THE CYCLE,

--> Display at 01:43:31:25
JUST LIKE
THE WATER CYCLE.

--> Display at 01:43:33:10
--> Erase at 01:43:35:20
IT KEEPS GOING ON
AND ON AND ON AND ON.

--> Display at 01:43:37:29
GREG HAS HEARD
OF THE WATER CYCLE

--> Display at 01:43:39:27
AND BELIEVES
THAT ENERGY CONTINUOUSLY

--> Display at 01:43:42:00
CYCLES
THROUGH A COMMUNITY.

--> Display at 01:43:43:15
BUT WE HAVE SEEN

--> Display at 01:43:44:25
THAT IN EVERY
CELLULAR TRANSACTION,

--> Display at 01:43:46:29
SOME ENERGY
IS RELEASED AS HEAT,

--> Display at 01:43:49:00
A FORM OF ENERGY

--> Display at 01:43:50:10
THAT ORGANISMS
ARE NOT ABLE TO USE.

--> Display at 01:43:53:04
IF ENERGY IS CONTINUALLY CONVERTED TO HEAT,

--> Display at 01:43:56:12
AND MADE UNAVAILABLE
TO LIFE AS A RESULT,

--> Display at 01:43:59:04
THEN HOW
COULD THERE BE

--> Display at 01:44:00:16
ENOUGH ENERGY
IN THE SYSTEM

--> Display at 01:44:01:26
TO SUSTAIN LIFE?

--> Display at 01:44:03:12
THERE ISN'T ENOUGH ENERGY.

--> Display at 01:44:06:10
EVEN THOUGH ENERGY
IS NOT LOST IN THE SYSTEM,

--> Display at 01:44:09:10
IT CANNOT BE RECYCLED

--> Display at 01:44:10:27
OVER AND OVER AGAIN
BY ORGANISMS.

--> Display at 01:44:13:13
HEAT IS A FORM OF ENERGY

--> Display at 01:44:15:12
THAT CAN'T BE ASSIMILATED
INTO FOOD CHAINS.

--> Display at 01:44:19:05
THIS IS WHY
THE FLOW OF ENERGY

--> Display at 01:44:21:08
THROUGH COMMUNITIES
IS A ONE-WAY TRIP.

--> Display at 01:44:23:25
TO FIND OUT MORE ABOUT THE END OF THE FOOD CHAIN,

--> Display at 01:44:26:07
--> Erase at 01:44:30:29
LET'S RETURN TO DR. LES KAUFMAN
AT THE PEARL HILL STATE PARK.

--> Display at 01:44:41:20
Kaufman: YOU HAVE TO REMEMBER THAT AN ANIMAL LIKE THIS

--> Display at 01:44:44:26
LYING DEAD ON THE FLOOR

--> Display at 01:44:46:06
ISN'T GOING TO BE A MEAL
FOR JUST ONE ORGANISM.

--> Display at 01:44:48:17
FIRST OF ALL,
BESIDES THE FUNGI COMING IN,

--> Display at 01:44:51:23
OR A CAT COMING BY
AND PICKING IT UP,

--> Display at 01:44:53:29
ALL OF THESE LARGER CREATURES ARE DEPENDENT UPON BACTERIA

--> Display at 01:44:58:18
TO BREAK DOWN SOME OF THE MORE STUBBORN CHEMICAL BONDS

--> Display at 01:45:03:02
AND MAKE THEM AVAILABLE
AS ENERGY, AS FOOD.

--> Display at 01:45:06:25
SO ALREADY,
THAT MOUSE CARCASS

--> Display at 01:45:09:18
IS RIDDLED
WITH ALL MANNER OF BACTERIA,

--> Display at 01:45:12:26
BREAKING IT DOWN,
PRE-DIGESTING IT, IF YOU WILL,

--> Display at 01:45:16:18
TO MAKE IT AVAILABLE
TO OTHER ORGANISMS.

--> Display at 01:45:20:24
Narrator: ANIMALS
ARE NOT THE ONLY THINGS

--> Display at 01:45:22:27
CONSUMED BY DECOMPOSERS.

--> Display at 01:45:24:20
BACTERIA AND FUNGI BREAK DOWN ALL DEAD THINGS,

--> Display at 01:45:28:00
PLANTS AND ANIMALS.

--> Display at 01:45:30:15
LOOK AT ALL THIS
DEAD STUFF DOWN HERE.

--> Display at 01:45:33:03
DEAD LEAVES,
SPENT PINE CONE,

--> Display at 01:45:36:28
WHAT'S THAT?
CORN ON THE COB.

--> Display at 01:45:41:20
AFTER LIVING THINGS DIE,

--> Display at 01:45:43:13
A LOT OF THE ENERGY

--> Display at 01:45:44:27
THAT WAS STORED
IN THEIR BODIES

--> Display at 01:45:47:10

WHEN THEY WERE ALIVE

--> Display at 01:45:49:02
IS STILL THERE.

--> Display at 01:45:50:16
BUT IT HASN'T BEEN USED,

--> Display at 01:45:52:04
BECAUSE THE CHEMICAL BONDS HOLDING THAT PART

--> Display at 01:45:55:00
OF THEIR BODY TOGETHER
ARE VERY STRONG.

--> Display at 01:45:57:19
THERE'S A PART OF THE FOOD WEB THAT'S VERY, VERY IMPORTANT

--> Display at 01:46:02:21
THAT TAKES
THIS RESIDUAL MATERIAL

--> Display at 01:46:04:09
AND GETS THE LAST OUNCE
OF ENERGY OUT OF IT.

--> Display at 01:46:08:04
OTHER THINGS, TOO.

--> Display at 01:46:09:19
AND WE HAVE A GOOD REPRESENTATIVE HERE,

--> Display at 01:46:13:01
IN THIS MUSHROOM, OF A PART
OF THIS DECOMPOSER COMMUNITY.

--> Display at 01:46:17:06
NOW, THAT MUSHROOM IS JUST

--> Display at 01:46:20:14
THE TIP OF THE ICEBERG,
YOU MIGHT SAY.

--> Display at 01:46:22:07
THIS IS JUST
THE REPRODUCTIVE STRUCTURE,

--> Display at 01:46:25:07
BUT IF WE PULL IT UP,
WE CAN SEE UNDERNEATH IT

--> Display at 01:46:29:00
THESE VERY, VERY FINE FIBERS,

--> Display at 01:46:32:10
WHICH ARE THE MAIN, PART
OF THE MAIN BODY OF THE FUNGUS.

--> Display at 01:46:35:08
THESE FIBERS REACH ALL AROUND THROUGH THE LITTER

--> Display at 01:46:38:15
AND HELP TO BREAK DOWN WHAT'S LEFT OF THE ORGANIC MATERIAL.

--> Display at 01:46:43:02
NOW, IN THIS CASE,

--> Display at 01:46:44:12
THE ENERGY HAS BEEN FLOWING

--> Display at 01:46:46:02
FROM THE LEAF LITTER
IN THIS BRANCH

--> Display at 01:46:49:00
TO THE FUNGUS, AND THE FUNGUS HAS USED SOME OF THAT ENERGY

--> Display at 01:46:53:11
TO SPRING UP
WITH THE FRUITING BODY.

--> Display at 01:46:56:09
THIS IS A SYMBIOTIC FUNGUS.

--> Display at 01:46:59:02
AND IT'S TIED IN

--> Display at 01:47:00:23
THROUGH THE ROOT HAIRS
OF THE TREES AROUND IT.

--> Display at 01:47:05:01
NOW, SOME OF THE ENERGY
FOR THIS MUSHROOM

--> Display at 01:47:09:04
IS BEING STOLEN FROM THE SUGAR IN THE ROOTS OF THESE TREES.

--> Display at 01:47:16:11
THE TREES GET
A GOOD DEAL OUT OF IT,

--> Display at 01:47:19:07
BECAUSE THE MUSHROOM IS MUCH MORE EFFICIENT THAN THE TREE

--> Display at 01:47:23:14
AT GETTING MOISTURE
AND SOME OF THE OTHER NUTRIENTS

--> Display at 01:47:27:02
LIVING THINGS NEED

--> Display at 01:47:28:14
OUT OF THE LEAF LITTER.

--> Display at 01:47:29:26
SO THE MUSHROOM AND THE TREE
ARE SYMBIONTS,

--> Display at 01:47:31:29
THEY'RE MUTUALISTS --
EACH HELPS THE OTHER.

--> Display at 01:47:35:10
SO ALL OF THESE TREES, THAT LOOK LIKE INDIVIDUALS TO US,

--> Display at 01:47:38:12
ARE KNITTED TOGETHER BY THIS FUNGAL NATION UNDERGROUND,

--> Display at 01:47:43:14
SHARING ENERGY AND MATERIALS.

--> Display at 01:47:46:07
ANYWAY, THIS MUSHROOM LIVES ENTIRELY BY BREAKING DOWN

--> Display at 01:47:53:10
ORGANIC MATTER.

--> Display at 01:47:54:27
IMAGINE WHAT THE WORLD
WOULD LOOK LIKE

--> Display at 01:47:57:12
IF WE DIDN'T HAVE
DECOMPOSERS AT WORK.

--> Display at 01:48:00:29
THIS IS THE ACCUMULATION
OF ONE GROWING SEASON --

--> Display at 01:48:05:25
OF PINE NEEDLES AND PINE CONES AND LEAVES.

--> Display at 01:48:12:15
IMAGINE THIS PILING UP
YEAR AFTER YEAR AFTER YEAR.

--> Display at 01:48:17:10
THERE'D BE MILES
OF THIS ORGANIC DETRITUS

--> Display at 01:48:20:28
IF DECOMPOSERS WEREN'T CONSTANTLY BREAKING IT DOWN.

--> Display at 01:48:24:21
EVEN THOUGH FUNGI
STILL HAVE SOME ENERGY CONTENT

--> Display at 01:48:27:28
AND CAN BE EATEN
BY OTHER CREATURES,

--> Display at 01:48:30:14
WE'RE PRETTY MUCH TALKING
ABOUT THE END OF THE LINE HERE.

--> Display at 01:48:34:08
EVENTUALLY,
THERE ISN'T ENOUGH ENERGY

--> Display at 01:48:36:18
LEFT
IN LITTER OR AN ORGANISM

--> Display at 01:48:40:06
FOR OTHER ORGANISMS TO FIND MUCH INTEREST IN IT.

--> Display at 01:48:42:10
NOW, WHY IS THAT?

--> Display at 01:48:43:23
WELL, EACH TIME ONE ORGANISM
IS CONSUMED BY ANOTHER,

--> Display at 01:48:48:21
MOST OF THE ENERGY IS LOST.

--> Display at 01:48:51:11
THINK BACK TO THE FIRE.

--> Display at 01:48:52:29
IT'S LOST AS HEAT,
IT'S CALLED RESPIRATORY LOSS,

--> Display at 01:48:56:23
AND WHERE DOES THAT
ULTIMATELY GO?

--> Display at 01:48:59:17
WELL, IT GOES UP INTO THE AIR,

--> Display at 01:49:01:17
IT'S RADIATED BACK INTO SPACE, WHERE IT CAME FROM.

--> Display at 01:49:04:25
SO YOU CAN'T GO THROUGH TOO MANY LINKS IN THE FOOD WEB

--> Display at 01:49:10:02
BEFORE THE ENERGY,
THAT PARCEL OF ENERGY,

--> Display at 01:49:13:10
IS GOING TO FIND ITSELF BACK UP IN SPACE, RADIATED OUT,

--> Display at 01:49:17:16
JUST AS THE ENERGY CAME IN
AS SUNLIGHT.

--> Display at 01:49:20:11
SO EVEN THE EARTH IS NOT CUT OFF FROM THE REST OF THE UNIVERSE.

--> Display at 01:49:25:20
ENERGY COMES IN FROM THE SUN

--> Display at 01:49:28:09
AND RADIATES BACK OUT TO SPACE
AS HEAT.

--> Display at 01:49:32:05
TO GET A BETTER SENSE
OF HOW MUCH HEAT IS PRODUCED,

--> Display at 01:49:36:02
WE PAID A VISIT
TO A COMPOSTING SITE,

--> Display at 01:49:38:23
WHERE WE CAN SEE AND HEAR

--> Display at 01:49:40:11
--> Erase at 01:49:43:11
EVIDENCE OF DECOMPOSERS
IN ACTION.

--> Display at 01:50:01:27
WE ARE LOCATED RIGHT NOW
IN FRONT OF A COMPOST PILE.

--> Display at 01:50:06:21
WE SEE VERY OBVIOUSLY
SOME PRODUCT

--> Display at 01:50:11:00
THAT CAME OUT
OF THE SCHOOL'S CAFETERIA.

--> Display at 01:50:14:19
THE BACTERIA AND FUNGI

--> Display at 01:50:16:07
WHO ARE THE DECOMPOSERS
IN THIS COMPOST PILE,

--> Display at 01:50:19:13
THEY ARE ESSENTIALLY INVISIBLE, BECAUSE THEY ARE MICROSCOPIC,

--> Display at 01:50:25:03
BUT THE EVIDENCE OF THEIR BEING THERE IS VERY OBVIOUS HERE,

--> Display at 01:50:30:09
BECAUSE OF THE BUBBLES THEY ARE PRODUCING

--> Display at 01:50:33:01
AS A RESULT OF DECOMPOSITION, AND PRODUCTION

--> Display at 01:50:35:27
OF CARBON DIOXIDE.

--> Display at 01:50:39:05
I AM GOING TO TAKE A MEASUREMENT OF THE TEMPERATURE

--> Display at 01:50:42:15
OF THE UPPER LAYER,
AS WELL AS INSIDE LAYER,

--> Display at 01:50:45:11
--> Erase at 01:50:49:08
OF THIS PARTICULAR PILE
OF GARBAGE.

--> Display at 01:50:52:05
THE TEMPERATURE IN THE UPPER LAYER IS ABOUT 20 DEGREES.

--> Display at 01:50:57:24
AND LET ME TRY THE SAME THING FOR THE DOWN,

--> Display at 01:51:02:21
--> Erase at 01:51:04:22
ON THE LOWER LAYER.

--> Display at 01:51:11:07
IT'S ABOUT 23 DEGREES.

--> Display at 01:51:16:08
SO, OBVIOUSLY,
SOME HEAT IS BEING GENERATED.

--> Display at 01:51:19:07
AND THERE IS VERY SIMPLE EXPLANATION.

--> Display at 01:51:22:22
THIS BACTERIA AND FUNGI,
THE DECOMPOSERS,

--> Display at 01:51:27:09
THEY HAVE TO UNDERGO,
PERFORM CELLULAR RESPIRATION

--> Display at 01:51:32:08
FOR THEIR OWN ENERGY TO LIVE.

--> Display at 01:51:34:14
AND THEY ARE USING THIS GARBAGE AS A SUBSTRATE, OR THEIR FOOD.

--> Display at 01:51:40:23
AND WHEN THEY BREAK IT DOWN, THEY PRODUCE, AS A BYPRODUCT,

--> Display at 01:51:45:14
HEAT.

--> Display at 01:51:47:16
WE HAVE JUST MOVED

TO ANOTHER AREA,

--> Display at 01:51:51:16
WHERE WE HAVE A PILE
OF LAWN CLIPPINGS.

--> Display at 01:51:57:22
AT LEAST 3 DEGREES WARMER INSIDE.

--> Display at 01:52:03:11
ALL RIGHT, WE ARE NOW IN
ANOTHER PILE, THE PILE OF FOOD

--> Display at 01:52:09:05
THAT CAME FROM
THE GRADE-SCHOOL CAFETERIA.

--> Display at 01:52:11:24
AND YOU CAN TELL
WHAT WAS NOT CONSUMED,

--> Display at 01:52:15:09
AND I'M GOING TO DO THE SAME EXPERIMENT ALL OVER AGAIN.

--> Display at 01:52:20:00
THE OUTSIDE TEMPERATURE HERE, IT'S ABOUT 20 DEGREES.

--> Display at 01:52:25:05
LESS THAN 20 DEGREES,
MORE LIKE 18.

--> Display at 01:52:28:11
AND HERE I GO INSIDE THE PILE,

--> Display at 01:52:31:28
WHERE THE HEAT IS BEING GENERATED, AS YOU CAN SEE,

--> Display at 01:52:35:26
IT'S, AND I'M GOING INSIDE
QUITE A BIT.

--> Display at 01:52:40:08
AND...

--> Display at 01:52:44:05
IT'S ABOUT 22 DEGREES.

--> Display at 01:52:46:28
--> Erase at 01:52:52:20
SO THE TREMENDOUS AMOUNT
OF HEAT IS BEING GENERATED.

--> Display at 01:52:55:06
WE LOOKED AT THREE DIFFERENT PILES OF GARBAGE.

--> Display at 01:52:59:02
AND WE NOTICED THERE ARE

THREE DIFFERENT TEMPERATURES.

--> Display at 01:53:02:13
THERE ARE DIFFERENT KINDS OF...

--> Display at 01:53:04:24
ORGANISMS ARE WORKING.

--> Display at 01:53:08:00
AND DIFFERENT KINDS OF GARBAGE

--> Display at 01:53:10:06
ARE BEING WORKED ON.

--> Display at 01:53:11:24
IN ALL CASES,
THEY ARE ALWAYS GENERATING HEAT

--> Display at 01:53:16:16
AS A RESULT OF DECOMPOSITION.

--> Display at 01:53:19:21
DECOMPOSERS
SUCH AS BACTERIA AND FUNGI

--> Display at 01:53:22:26
ABSORB ENERGY STORED
IN DEAD PLANTS AND ANIMALS.

--> Display at 01:53:25:24
THEY CONSUME THEM FOR ENERGY
AND RELEASE HEAT IN THE PROCESS,

--> Display at 01:53:29:25
JUST LIKE WE DO.

--> Display at 01:53:31:18
WE'RE NEARING THE END
OF TODAY'S SESSION.

--> Display at 01:53:34:15
--> Erase at 01:53:36:05
LET'S REVIEW
SOME OF THE BIG IDEAS.

--> Display at 01:53:39:16
PLANTS AND OTHER PRODUCERS
MAKE THEIR OWN FOOD,

--> Display at 01:53:42:07
--> Erase at 01:53:43:25
USING ENERGY FROM SUNLIGHT.

--> Display at 01:53:46:09
Zook: LIGHT ENERGY IS CONVERTED TO CHEMICAL ENERGY

--> Display at 01:53:48:29

IN THE PROCESS
OF PHOTOSYNTHESIS.

--> Display at 01:53:53:09
THE PRODUCERS ARE THE FIRST LINK IN THE FOOD CHAIN.

--> Display at 01:53:55:28
WITHOUT THEM, THE EARTH'S ENERGY IS UNAVAILABLE

--> Display at 01:53:58:16
--> Erase at 01:54:00:08
TO NEARLY ALL LIVING THINGS.

--> Display at 01:54:03:17
CHEMICAL ENERGY
IS STORED IN FOOD

--> Display at 01:54:06:07
--> Erase at 01:54:09:03
AND TRANSFERRED
THROUGH FOOD CHAINS.

--> Display at 01:54:12:13
Grisham: IF WE ACCOUNT
FOR THE ENERGY

--> Display at 01:54:14:20
THAT REACHES
EACH STAGE OF THE FOOD CHAIN,

--> Display at 01:54:16:23
WE SEE HOW ENERGY,
THAT ENTERED THE SYSTEM

--> Display at 01:54:19:16
--> Erase at 01:54:23:25
AS SUNLIGHT, EVENTUALLY
LEAVES THE SYSTEM AS HEAT.

--> Display at 01:54:26:10
Zook: ENERGY IS USED TO FUEL LIVING ORGANISMS,

--> Display at 01:54:29:19
BUT THIS IS NOT A PERFECTLY EFFICIENT PROCESS.

--> Display at 01:54:32:19
THE DECOMPOSERS REMIND US THAT ENERGY, IN THE FORM OF HEAT,

--> Display at 01:54:38:07
IS CONTINUALLY RENDERED UNUSABLE

--> Display at 01:54:40:11
TO THE LIVING WORLD,

--> Display at 01:54:41:28
AS IT MOVES THROUGH FOOD CHAINS,

--> Display at 01:54:44:00
AND THAT A CONSTANT
INFLUX OF ENERGY

--> Display at 01:54:46:06
--> Erase at 01:54:49:15
IS NEEDED TO SUPPORT LIFE.

--> Display at 01:54:51:11
SO THE PATH ENERGY TAKES
THROUGH COMMUNITIES IS LINEAR.

--> Display at 01:54:54:27
THERE IS A DEFINITE BEGINNING

--> Display at 01:54:56:12
AND DEFINITE ENDPOINT.

--> Display at 01:54:58:14
THE ENERGY NEEDED
TO SUSTAIN NEARLY ALL LIFE

--> Display at 01:55:02:03
COMES FROM THE SUN,
AND FOR THIS REASON,

--> Display at 01:55:04:29
--> Erase at 01:55:08:25
ENERGY FLOW IS AN OPEN SYSTEM.

--> Display at 01:55:19:15
LIFE COMES IN FANTASTIC VARIETY.

--> Display at 01:55:22:18
THERE ARE SO MANY DIFFERENT SPECIES OF LIVING THINGS,

--> Display at 01:55:25:09
WE'RE NOT EVEN SURE
QUITE HOW MANY.

--> Display at 01:55:27:06
MAYBE 2 MILLION HAVE BEEN NAMED,

--> Display at 01:55:29:02
THERE MAY BE
UP TO 30 MILLION OTHERS

--> Display at 01:55:31:06
WE HAVEN'T EVEN NOTICED YET.

--> Display at 01:55:32:23
BUT DESPITE THIS PHENOMENAL DIVERSITY,

--> Display at 01:55:36:27
THE BASIC PRINCIPLES
BY WHICH LIFE OPERATES

--> Display at 01:55:40:15
ARE HELD IN COMMON
ACROSS ALL THE LIVING WORLD.

--> Display at 01:55:43:25
ALL LIFE REQUIRES ENERGY,

--> Display at 01:55:46:11
AND THE VAST BULK OF THAT ENERGY COMES FROM THE SUN.

--> Display at 01:55:51:15
IT WOULD BE NICE
TO THINK ABOUT THIS

--> Display at 01:55:53:18
THE NEXT TIME YOU'RE WATCHING
A BEAUTIFUL SUNSET.

--> Display at 01:55:56:09
THE LIGHT FALLING ON YOUR FACE

--> Display at 01:55:59:08
--> Erase at 01:56:04:02
IS ULTIMATELY THE VERY ENERGY THAT MOVES YOU THROUGH THE DAY.

--> Display at 01:56:07:17
Zook: THE ENERGY NEEDED
TO SUSTAIN NEARLY ALL LIFE

--> Display at 01:56:10:20
COMES FROM THE SUN.

--> Display at 01:56:12:28
A CONSTANT SUPPLY OF NEW
ENERGY ARRIVES ON EARTH

--> Display at 01:56:15:13
IN THE FORM
OF SUNLIGHT.

--> Display at 01:56:16:26
THIS IS VERY DIFFERENT
FROM NUTRIENTS,

--> Display at 01:56:19:13
AS WE WILL SEE
NEXT TIME,

--> Display at 01:56:21:05
WHEN WE'LL
BE LOOKING

--> Display at 01:56:22:15
AT THE MATERIAL
BUILDING BLOCKS

--> Display at 01:56:23:26

OF ORGANISMS, COMMUNITIES,
AND THEIR ENVIRONMENTS.

--> Display at 01:56:27:02
WE'LL BE ASKING
HOW MATERIALS

--> Display at 01:56:28:27
CYCLE
THROUGH COMMUNITIES,

--> Display at 01:56:30:11
FROM PRODUCERS

--> Display at 01:56:31:21
TO CONSUMERS
AND DECOMPOSERS.

--> Display at 01:56:34:02
--> Erase at 01:56:36:14
Both: SEE YOU NEXT TIME!

--> Display at 01:57:54:19
FOR INFORMATION ABOUT THIS

--> Display at 01:57:56:13
AND OTHER ANNENBERG/CPB PROGRAMS,

--> Display at 01:57:58:27
CALL 1-800-LEARNER

--> Display at 01:58:01:05
--> Erase at 01:58:05:23
AND VISIT US
AT www.learner.org.

--> Display at 01:58:16:29
FUNDING FOR THIS PROGRAM
IS PROVIDED BY ANNENBERG/CPB,

--> Display at 01:58:20:22
--> Erase at 01:58:22:24
TO ADVANCE EXCELLENT TEACHING.

--> Display at 01:58:24:25