

Big Picture Podcast – Episode 16

The Chemistry of Water, Part 1 (Chapter 8B)

Do-The-Review

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Co-hosts John Suchocki and Marjorie Suchocki review the first half of the Conceptual Chemistry chapter on the properties of water. Topics include the open crystalline structure of ice, why ponds freeze from the top down, how salt melts ice, and the properties of liquid water at its surface involving surface tension and capillary action. We review all these topics from the molecular point of view. Duration: 44:09.

Our apologies for the poor quality of this transcript. We are currently looking into how to solve this issue.

Marjorie: Ice has water on the top of it. And that's why you can do the ice skating, that's really weird. You would think they were skating on ice, but they aren't. So why do we say he's skating on ice when actually he's skating on water?

John: That's a good point.

Marjorie: It is.

John: Can you introduce us?

Marjorie: Welcome to the Big Picture podcast. My name is Marjorie Sparky and I am here as your co-host as we explore this chapter on water.

John: Mom, thank you so much for joining us here.

Marjorie: I'm glad to do this and

John: Quite

Marjorie: Quite

John: The

Marjorie: The

John: Honor.

Marjorie: Honor.

John: Welcome

Marjorie: Welcome

John: To

Marjorie: To

John: The

Marjorie: The

John: Do

Marjorie: Do review

John: Review section

Marjorie: Section.

John: For this chapter on how water behaves. In this chapter, we start with water in the solid phase and we move to the liquid phase and then to the gaseous phase. We'll be exploring the multitude of amazing properties for the water molecule very dear to all of our hearts. So here we are, the first section. Water molecules form an open crystalline structure in ice.

Marjorie: Mike, does it look like at the level of molecules so.

John: Well, recall earlier we've talked about water being analogous to a bunch of marbles in a bag. The marbles can tumble over one another and you can pour the marbles out of the bag, kind of like a fluid. Let me say exactly like a fluid. Consider the water molecules like tiny, tiny, tiny little marbles. And when you have the water within a cup and you pour the water out, in vision, all those tiny, tiny, tiny water molecules tumbling over one another as they flow out of the cup. So that's perhaps the best place to begin of thinking of liquid water as a bunch of marbles tumbling over one another.

Marjorie: They

John: Like

Marjorie: Like

John: Tumbling.

Marjorie: Tumbling.

John: Yeah,

Marjorie: It's

John: In

Marjorie: Their nature

John: Nature.

Marjorie: To tumble.

John: But they

Marjorie: They

John: Also

Marjorie: Also

John: Like

Marjorie: Like.

John: Each other because remember, we talked about the dipole dipole attractions.

Marjorie: Oh, yeah. So actually, they're playing with each other. Speaking as your mother.

John: That's

Marjorie: That's a

John: A good

Marjorie: Good way

John: Way to

Marjorie: To put

John: Put

Marjorie: It.

John: It.

Marjorie: Ok.

John: For each

Marjorie: Water.

John: Water molecule, one side slightly negative, the other side slightly positive. Each water molecule has a dipole which makes them slightly sticky.

Marjorie: So

John: So two water

Marjorie: Automl.

John: Molecules are attracted to each other by the dipole dipole attraction. So what we're gonna do now is we're going to lower the temperature of this water.

Marjorie: I bet that means they won't run quite so fast.

John: As you remove the energy from the system. Yeah, indeed, you will find the molecules start to slow down. They'll slow down to the point where the molecules can no longer tumble over one another quite so well and they become eventually immobile ruts. Yeah, that's what you have in a solid phase.

Marjorie: Ofwater.

John: The water molecules are all found in fixed positions.

Marjorie: Wow. So while they are a full of these molecules that have a tendency to run in an

John: Tumble over

Marjorie: Interval

John: One another.

Marjorie: Of one another,

John: Yeah.

Marjorie: What's required in order for that to happen is a certain level

John: Energy

Marjorie: Of temperature. Heat.

John: Hit heat. Yeah,

Marjorie: Yeah,

John: Yeah.

Marjorie: Yeah.

John: And if you remove that heat, there's rude, rude to the point that they become fixed in their positions.

Marjorie: They fall asleep.

John: Well, not really, because it's quite interesting. Think of it this way. They're no longer tumbling around one another. But that's not to say they're not moving.

Marjorie: Well,

John: Well,

Marjorie: How

John: How

Marjorie: Are

John: Are

Marjorie: They

John: They

Marjorie: Moving?

John: Moving? The zoo is

Marjorie: Like moving

John: Moving in

Marjorie: In

John: Place.

Marjorie: Place.

John: Yes, they're vibrating in place.

Marjorie: Okay. Yeah.

John: So once you get them all frozen in a solid phase, is it possible to get any colder?

Marjorie: Actually,

John: Actually,

Marjorie: I

John: I

Marjorie: Would

John: Would

Marjorie: Say

John: Say

Marjorie: No.

John: No. But you see, what's the difference between ice at minus 10 degrees in ice at minus 50 degrees?

Marjorie: Is there any difference?

John: Very

Marjorie: Very

John: Much

Marjorie: Much

John: So.

Marjorie: So. Why?

John: Well, which

Marjorie: Which

John: Has

Marjorie: Has

John: More

Marjorie: More

John: Energy.

Marjorie: Energy?

John: Oh,

Marjorie: Oh, the

John: The

Marjorie: One-ton.

John: London.

Marjorie: The.

John: The

Marjorie: The

John: Ones

Marjorie: Ones

John: With

Marjorie: With

John: Higher temperature,

Marjorie: Higher temperature,

John: Which

Marjorie: Right?

John: Is minus

Marjorie: Minus

John: 10

Marjorie: 10

John: Degrees.

Marjorie: Degrees. Yes.

John: So

Marjorie: So.

John: Would

Marjorie: Well,

John: You believe

Marjorie: So. Weinmann

John: It? They

Marjorie: They

John: Vibrate

Marjorie: Vibrate

John: More

Marjorie: More

John: Slowly

Marjorie: Slowly

John: As

Marjorie: As

John: What

Marjorie: What

John: You're

Marjorie: You're

John: Saying

Marjorie: Saying

John: At

Marjorie: At

John: Lower

Marjorie: Lower

John: Temperatures.

Marjorie: Temp, at lower temperatures.

John: Yeah.

Marjorie: And can

John: You

Marjorie: You

John: Get

Marjorie: Get

John: To

Marjorie: To

John: A

Marjorie: A

John: Rock

Marjorie: Rock

John: Bottom

Marjorie: Bottom

John: Temperature

Marjorie: Temperature

John: Where

Marjorie: Where

John: They

Marjorie: They

John: Don't

Marjorie: Don't vibrate

John: Vibrate at

Marjorie: At

John: All.

Marjorie: All?

John: And that

Marjorie: That

John: Would

Marjorie: Would

John: Be

Marjorie: Be

John: Absolute

Marjorie: Absolute

John: Zero.

Marjorie: Zero.

John: Yes.

Marjorie: Yes.

John: Can

Marjorie: Can they

John: They do

Marjorie: Do

John: That?

Marjorie: That?

John: No,

Marjorie: No,

John: It's

Marjorie: It's

John: A

Marjorie: A

John: Theoretical

Marjorie: Theoretical.

John: Plane.

Marjorie: Really?

John: Really? You

Marjorie: You

John: Can't

Marjorie: Can't

John: Extract

Marjorie: Extract

John: All

Marjorie: All

John: That

Marjorie: That

John: Energy.

Marjorie: Energy.

John: It takes an infinite

Marjorie: No

John: Amount of energy to extract that.

Marjorie: Kidding.

John: We

Marjorie: We

John: Talked

Marjorie: Talked

John: About

Marjorie: About

John: That

Marjorie: That.

John: At absolute zero. Only then do you get rid of the vibrational motion. I

Marjorie: I

John: Think

Marjorie: Think

John: That's

Marjorie: That's

John: Amazing.

Marjorie: Amazing.

John: Yeah. So

Marjorie: So

John: Water.

Marjorie: Wait a minute,

John: Wait

Marjorie: Wait

John: A minute.

Marjorie: A minute.

John: What does

Marjorie: Does that

John: That.

Marjorie: Mean they're dead or can they be resuscitated with heat?

John: Now, I

Marjorie: I

John: Think

Marjorie: Think

John: If

Marjorie: If

John: You

Marjorie: You

John: Added

Marjorie: Did,

John: The heat,

Marjorie: They

John: They would

Marjorie: Would start.

John: Start vibrating.

Marjorie: Ha ha. OK.

John: So they're not tumbling over one another, they're stuck. But when they're stuck positions, they are still vibrating.

Marjorie: Brady

John: Yeah.

Marjorie: Here.

John: Now, here's the interesting part in terms of how they are fixed relative to one another.

Marjorie: Yeah, that's interesting.

John: Recall

Marjorie: Recall water

John: Water has

Marjorie: Has a

John: A

Marjorie: Bent

John: Bent

Marjorie: Shape

John: Shape

Marjorie: To

John: To

Marjorie: It.

John: It.

Marjorie: Yes,

John: Yes,

Marjorie: I

John: I

Marjorie: Remember.

John: Remember. Yeah.

Marjorie: Yeah.

John: So.

Marjorie: Weird.

John: Well, we're going over this earlier. The water molecules a bent shape and that comes from the tetrahedral nature of

Marjorie: It's.

John: Its electron geometry. And from that tetrahedron nature you'll find the what each water molecule, extensive self and four different directions. And just add it all up. You end up with this crystalline structure. That's an open crystalline structure, like a jungle gym, maybe on a playground. You've got the kid can run through all the bars.

Marjorie: Here's.

John: What's in those bars is the empty space. And at the intersection of each bar, that's where you have your water molecule.

Marjorie: Okay.

John: The water molecules are stuck in place in this what we call an open crystalline

Marjorie: Instruct

John: Structure.

Marjorie: Her.

John: And there's the space that's in-between those water molecules. And as it forms this crystal and structure, it has this tendency to pucker up. It actually occupies more volume. Once it freezes,

Marjorie: Oh, it

John: It expands,

Marjorie: Expands,

John: It

Marjorie: It

John: Expands

Marjorie: Expands. Of course it does

John: Significantly.

Marjorie: Inefficiently

John: And

Marjorie: And

John: You

Marjorie: You

John: Know

Marjorie: Know

John: That

Marjorie: That if

John: If you

Marjorie: You

John: Take

Marjorie: Take

John: Water

Marjorie: Water

John: In

Marjorie: In

John: A

Marjorie: A

John: Jar

Marjorie: Jar

John: And

Marjorie: And

John: You

Marjorie: You

John: Close

Marjorie: Close

John: The

Marjorie: The

John: Jar

Marjorie: Jar

John: And

Marjorie: And

John: Then

Marjorie: Then

John: You

Marjorie: You

John: Put

Marjorie: Put

John: It

Marjorie: In

John: In

Marjorie: Your

John: Your freezer,

Marjorie: Freezer. Oh, yeah.

John: What

Marjorie: What

John: Happens

Marjorie: Happens

John: To

Marjorie: To

John: The

Marjorie: The

John: Jar?

Marjorie: Jar

John: It cracks

Marjorie: Cracks

John: Because

Marjorie: Because

John: The

Marjorie: The

John: Water's

Marjorie: Water is

John: Expanding.

Marjorie: Expanding. I know.

John: So

Marjorie: So

John: When

Marjorie: When

John: Water

Marjorie: Water.

John: Freezes all those water molecules, they enter into this open crystalline structure that puckers out, occupying much more of the the

Marjorie: Volume.

John: Volume, more space.

Marjorie: I was imagining something. I was imagining when I was a kid, we used to play down in the marsh and we used to go in these old houses that sometimes people lived in and most of the time they didn't. And there was a jug of water on the table.

John: Abel,

Marjorie: And my

John: My friend.

Marjorie: Friend and I said, Oh, look, somebody has been here. Next time we came, they'd been oppressed. And when we came and there was glass all

John: All

Marjorie: Over

John: Over

Marjorie: The

John: The place,

Marjorie: Place and the water was gone.

John: The jug, glass

Marjorie: And

John: Jug.

Marjorie: Yes,

John: Yes.

Marjorie: It was glass jug. And we knew that someone had come in while we

John: We've

Marjorie: Were gone and broken

John: Broken

Marjorie: That

John: That

Marjorie: Jar

John: Shot

Marjorie: Goal

John: Of

Marjorie: Of

John: Water.

Marjorie: Water.

John: The

Marjorie: The

John: Mystery

Marjorie: Mystery

John: Has

Marjorie: Has

John: Been

Marjorie: Been

John: Finally

Marjorie: Fine. Yes,

John: Solved.

Marjorie: I know it. I know it.

John: It

Marjorie: But

John: Did

Marjorie: It's.

John: It itself.

Marjorie: So we

John: We had

Marjorie: Had

John: More

Marjorie: More

John: Time

Marjorie: Time

John: And

Marjorie: Imagining

John: Met

Marjorie: Who the

John: The robber

Marjorie: Robber

John: Was

Marjorie: Was.

John: In the

Marjorie: Game

John: Game. And

Marjorie: And pretty

John: I think

Marjorie: Quick

John: That glass

Marjorie: Glass

John: Of

Marjorie: Of what? That

John: That jug

Marjorie: Jug

John: Of

Marjorie: Of

John: Water.

Marjorie: Water. Yeah. So see, when you talk about water expanding when it gets colder, I instantly remember

John: Rambam.

Marjorie: The phantom thief. It's

John: So

Marjorie: A.

John: There's an interesting question to ask. There is space in between. Yes,

Marjorie: Yes.

John: Those water

Marjorie: Watermill.

John: Molecules.

Marjorie: Well, it

John: Yeah,

Marjorie: Fills that

John: That's

Marjorie: Space

John: What

Marjorie: With.

John: Feels that. Space A. Air B, water vapor C, nothing.

Marjorie: Nothing. Nothing.

John: Nothing. Absolutely nothing. That's correct. Good job.

Marjorie: I thought

John: Nature

Marjorie: Nature

John: Employed

Marjorie: Abhors

John: To

Marjorie: A

John: Vacuum.

Marjorie: Vacuum.

John: Well, there it is. There's your vacuum.

Marjorie: Huh.

John: Yeah, we do mean open space. Literally space like the Starship Enterprise could go whizzing through there.

Marjorie: Well,

John: If

Marjorie: If it

John: It were

Marjorie: Were

John: Small

Marjorie: Small,

John: Enough

Marjorie: If it were.

John: About

Marjorie: Why

John: Iceland

Marjorie: Doesn't it

John: Collapse

Marjorie: Collapse

John: On

Marjorie: On

John: Itself.

Marjorie: Itself?

John: Why doesn't a building collapse on itself? There's the architecture. Right. You build the iron grids just so that it's self-supporting.

Marjorie: Yeah, that's right.

John: It's the architecture. Because

Marjorie: Oh,

John: The architecture

Marjorie: Architecture.

John: That

Marjorie: So

John: Prevents

Marjorie: The

John: That

Marjorie: Architecture

John: Perhaps any of

Marjorie: Of

John: The.

Marjorie: The molecule itself is what keeps it from falling in on itself.

John: There's the

Marjorie: The.

John: Architect of the molecule and then the architecture of all those molecules together.

Marjorie: Yes.

John: All those molecules together building a superstructure, which we called this open space crystalline structure of

Marjorie: How

John: Ice.

Marjorie: Interest and that

John: Yeah.

Marjorie: Makes it beautiful. OK. What comes next?

John: Next, we're going to talk about the melting process. OK,

Marjorie: Ok.

John: Got to go from the solid phase now to the liquid phase. Is

Marjorie: Is

John: It

Marjorie: It

John: Any

Marjorie: Any

John: More

Marjorie: More than

John: Than

Marjorie: The

John: The fact

Marjorie: Fact that

John: That he

Marjorie: He

John: Does

Marjorie: Is

John: Apply?

Marjorie: Applied?

John: No, that's

Marjorie: That's

John: All.

Marjorie: All, that's

John: That's it.

Marjorie: It.

John: Let's consider an ice cube in water. All right. In liquid water. So you have an ice cube submerged in liquid water. Now, in the ice cube, you find all those water molecules are stuck in their fixed positions

Marjorie: Here saturate.

John: Right outside the ice cube and liquid water. They're all tumbling over one another.

Marjorie: That's

John: Or as

Marjorie: Right.

John: You

Marjorie: You

John: Say

Marjorie: Say

John: There,

Marjorie: They're

John: They're

Marjorie: They're

John: Playing.

Marjorie: Playing here.

John: Yeah. So what we want to look at here is what's happening at the interface

Marjorie: Yes,

John: Between

Marjorie: I mean,

John: The

Marjorie: The solid

John: Solid

Marjorie: Hunter.

John: Water and the liquid water. And here's some people don't quite realize freezing and melting go on at the same time. It's a dynamic process at the surface. You will find

water molecules leaving the ice, going into the liquid water. And at that surface, you will also have liquid water molecules that attached to the ice surface and get stuck.

Marjorie: Oh,

John: So

Marjorie: So

John: You

Marjorie: You

John: Have

Marjorie: Have

John: A

Marjorie: A

John: Melting

Marjorie: Melting

John: Process

Marjorie: Process? Oh,

John: Of

Marjorie: Of

John: Water

Marjorie: Course.

John: Molecules leaving the ice cube to the liquid and you also have a freezing process of water molecules going from the liquid to the ice.

Marjorie: It's

John: Let's look at it from

Marjorie: From.

John: The point of view of a water molecule that that's a liquid. Right. There you are, a water molecule playing around with your neighbors,

Marjorie: In

John: Tumbling

Marjorie: A

John: Over

Marjorie: Room.

John: One another, having a good time. Then suddenly you hit into this ice cube. Yes, you'll get stuck like a fly in fly paper.

Marjorie: Wait a minute, I thought an ice cube in water would melt, but it

John: It

Marjorie: Hit

John: Does

Marjorie: Us. But

John: It does both

Marjorie: But

John: Disappoint

Marjorie: It also

John: Also.

Marjorie: At the same time that are munden respect, it's melting in another respect. As it loses, it also adds.

John: Yes, it's kind of like a revolving door at a department store. You got people going out of the store. You got people going into the store.

Marjorie: Right.

John: Right. And when they're leaving the store, let's say that's water going from the solid to the liquid phase. When they're entering the store through the revolving door, it's like from the liquid into the solid phase. So the store represents the ice cube. We have a rate at which water molecules are leaving and we can have a rate at which water molecules are entering. And when you take ice and you throw it into water, that is at zero degrees Celsius. Yes. What's special about zero degrees Celsius

Marjorie: What is

John: Special.

Marjorie: Special

John: That's

Marjorie: About zero degrees Celsius,

John: At zero

Marjorie: Zero.

John: Degrees Celsius. The rate at which they leave the department store is equal to

Marjorie: It's

John: The rate

Marjorie: The same as those coming in.

John: As they go in.

Marjorie: So

John: So it's

Marjorie: It's

John: The

Marjorie: A Stacie's.

John: Stakes. That's it. Good word. Meaning it doesn't change. Well, it's weird on a molecular level. All sorts of stuff happening, but at zero degrees, you will be able to have your ice cube indefinitely. Yeah.

Marjorie: Yes,

John: There

Marjorie: There

John: Will

Marjorie: Will.

John: Be

Marjorie: Wow.

John: Water molecules leaving that ice cube in. Come in back into the ice cube. Back and forth, back

Marjorie: Yes.

John: And forth, back,

Marjorie: Yes,

John: Forth

Marjorie: Yes.

John: On a molecular level. It's really dynamic. The ice cube might be going through different water molecules, but you're still going to have the

Marjorie: Yes.

John: Ice cube.

Marjorie: Yes. So it doesn't

John: Now,

Marjorie: Melt.

John: Overall, yeah. So it's a it's a dynamic

Marjorie: Wait,

John: Process.

Marjorie: Let me ask you something else.

John: But does

Marjorie: Does

John: It

Marjorie: It

John: Still

Marjorie: Still

John: Cool?

Marjorie: Cool

John: The

Marjorie: The

John: Water,

Marjorie: Water?

John: The ice cube cools the water. But guess what? The liquid water warms up the ice cube at zero degrees Celsius. The to balance each other

Marjorie: Oh.

John: Perfectly. Just take two water molecules

Marjorie: Yes.

John: In space.

Marjorie: Mm hmm.

John: They're both dipoles and so they're attracted to each other as those water molecules come toward each other. They

Marjorie: They.

John: Accelerate toward one another. And as soon as they collide, they start vibrating and spinning around each

Marjorie: Sure.

John: Other like crazy.

Marjorie: Crazy.

John: So

Marjorie: Yeah.

John: What happens

Marjorie: Happens.

John: Is you might have two water molecules that are out in space not rotating or doing anything. And as they accelerate toward one another, they're picking ups B.

Marjorie: Oh, of course.

John: And once they do hit, they start vibrating like crazy. So after they collide, suddenly they're moving like crazy. Remember we talked about temperature. The higher the temperature, the faster they're moving. Do you understand? Can you recognize that when they come together like that? Suddenly the temperature is higher? Sure.

Marjorie: Sure.

John: It because

Marjorie: Because

John: They're

Marjorie: They're

John: Moving

Marjorie: Moving

John: Faster.

Marjorie: Fast.

John: Right.

Marjorie: Right.

John: So we say it like this when two water molecules come together. Energy is released. So now say out in outer space, you had two water molecules that were stuck together.

Marjorie: Yes.

John: Yes. And you wanted to pull them apart.

Marjorie: O

John: Oh,

Marjorie: O.

John: It's going to cost you energy, isn't it?

Marjorie: Yes.

John: Because

Marjorie: Is

John: They're

Marjorie: There?

John: Stuck like pulling two magnets apart

Marjorie: Right

John: Who

Marjorie: To each.

John: You're trying to pull to water molecules apart. They're going to. I know. I don't believe my neighbor were attracted. We've

Marjorie: You've

John: Got

Marjorie: Got.

John: Both negative and positive charges and we're

Marjorie: Fine.

John: Fine.

Marjorie: We're perfect.

John: Leave

Marjorie: Leave

John: Us

Marjorie: Us alone.

John: Alone.

Marjorie: Yes.

John: If you wanted to pull them apart, you would have to put an energy.

Marjorie: You

John: I

Marjorie: Would

John: Would

Marjorie: Have to put a heavy energy and force there to force

John: Force

Marjorie: Them

John: Them

Marjorie: Apart whether they liked

John: To do

Marjorie: It or not.

John: So when the water molecules come together. Energy is released

Marjorie: He answer

John: Once they're

Marjorie: To.

John: Together, if you want to pull them apart. That requires energy.

Marjorie: That's

John: It's

Marjorie: Right.

John: The opposite.

Marjorie: You got to put

John: Put it

Marjorie: It back

John: Back

Marjorie: In.

John: In. Now, that's important to understand that whenever a liquid water molecule collides with the surface of the ice cube. Yes. It warms up. Because you're doing exactly that, you're forming

Marjorie: Oh, of course.

John: A bond and interaction between that water molecule and this water molecule.

Marjorie: Yes.

John: So when the water goes from the liquid to the solid phase, energy is released. Freezing is the energy

Marjorie: Energy

John: Releasing

Marjorie: Process.

John: Process

Marjorie: Oh, my goodness.

John: Because

Marjorie: Because

John: You're

Marjorie: You're.

John: Pulling water molecules together and energy is released. That's what freezing is. Look at the reverse. If you wanted to pull those water molecules away from the crystal in structure, that's going to cost you energy. That's going to cool things down. So going from the solid phase to the liquid phase, that requires energy. So here's what happens. You have water and ice together at zero degrees Celsius. Got

Marjorie: That.

John: That. And at that zero degrees Celsius, you realize ice being formed in the same time ice is being formed in the amount of energy that's being released from the formation of ice is equal to the amount of energy you lose. In

Marjorie: In

John: The

Marjorie: The

John: Opposite

Marjorie: Opposite

John: Direction,

Marjorie: Direction.

John: It

Marjorie: It

John: Balances

Marjorie: Balances

John: Out.

Marjorie: Out. Now

John: Now what

Marjorie: What

John: We're

Marjorie: We're

John: Gonna

Marjorie: Gonna

John: Do

Marjorie: Do

John: Is

Marjorie: Is

John: We're

Marjorie: We're

John: Going

Marjorie: Going to

John: To perturb

Marjorie: Perturb

John: The

Marjorie: The

John: Situation.

Marjorie: Situation. Oh,

John: We're

Marjorie: We're

John: Going

Marjorie: Gonna

John: To start

Marjorie: Start

John: Adding

Marjorie: Adding heat.

John: Heat,

Marjorie: Yes.

John: An external

Marjorie: External

John: Source

Marjorie: Source.

John: Of heat, maybe a flame, maybe a little like electric current. It starts warming up and we get it to not zero degrees, but maybe five degrees Celsius.

Marjorie: Huh?

John: You're

Marjorie: You're adding

John: Adding energy.

Marjorie: Energy. Yes.

John: Yes,

Marjorie: So

John: I guess.

Marjorie: It's going to start to break up.

John: Yeah.

Marjorie: Yeah.

John: Guess which process you're going to favor? The one where you're breaking up, which requires the input of energy. Yeah. So you are favoring

Marjorie: Savery.

John: The leaving of water molecules from the ice cube into the liquid water. So you will find what happens to the ice cube while

Marjorie: Well,

John: The

Marjorie: The ice

John: Ice

Marjorie: Cube melts.

John: Melts. You could do the reverse process. You could remove energy, lower the temperature from zero degrees to minus five degrees. And you are going to favor liquid water molecules going into the ice cube, which releases energy that needs to be removed. Let's look at it this way. And this is counterintuitive. Right. Freezing is a warming process. Freezing is a warming process. Now, explain that

Marjorie: But it is

John: Warming.

Marjorie: A warming process.

John: Because you're forming bonds between water molecules and as you form those bonds, heat is released. Yes.

Marjorie: Yes.

John: Yeah. And you know what? The only way to make it so that those water molecules stay together

Marjorie: Like

John: Like that

Marjorie: That? Yeah.

John: Is to make sure you remove that heat that was formed. And if you don't remove that heat that was formed, they're going to come right back out. And that's the function of a refrigerator. It removes that heat. Because if you don't I'm sorry, this it's going to melt again. Yeah,

Marjorie: Ken

John: So

Marjorie: Suf.

John: Freezing counterintuitive, I know as it may sound, freezing is a warming process.

Marjorie: Isn't that amazing?

John: Now

Marjorie: Now

John: Let's

Marjorie: Let's flip

John: Flip

Marjorie: It

John: It around.

Marjorie: Around. Nobody

John: Nobody

Marjorie: Would

John: Would

Marjorie: Believe

John: Believe it

Marjorie: It.

John: Melting.

Marjorie: Melting 0

John: Oh,

Marjorie: Is

John: Is

Marjorie: A

John: A

Marjorie: Cooling

John: Cooling

Marjorie: Process.

John: Cooling

Marjorie: Process?

John: Process.

Marjorie: Absolutely.

John: Absolutely.

Marjorie: Explain

John: Explain

Marjorie: That

John: That

Marjorie: One.

John: One now.

Marjorie: I can't. Too much

John: Oh, mom. Melting is a

Marjorie: Cooling

John: Cooling process.

Marjorie: Brass. Well, it's

John: If melting.

Marjorie: Melting.

John: What

Marjorie: What was

John: Was

Marjorie: That

John: That mean?

Marjorie: Mean?

John: That

Marjorie: That

John: Means

Marjorie: Means you

John: You

Marjorie: Have

John: Have water

Marjorie: Water molecules

John: Molecules

Marjorie: Are

John: Are

Marjorie: Together.

John: Together.

Marjorie: Yeah.

John: Yeah.

Marjorie: Stuck

John: Stuck

Marjorie: In

John: In

Marjorie: A

John: A

Marjorie: Solid

John: Solid

Marjorie: Phase.

John: Phase and

Marjorie: No,

John: You want

Marjorie: I want them

John: Them

Marjorie: To

John: To pull

Marjorie: Help.

John: Apart

Marjorie: You

John: So

Marjorie: Want

John: They can

Marjorie: Them

John: Go

Marjorie: To

John: To

Marjorie: Start

John: Liquid

Marjorie: Playing

John: Phase.

Marjorie: Again?

John: You

Marjorie: You

John: Want

Marjorie: Want

John: To

Marjorie: To

John: Start

Marjorie: Start

John: Playing

Marjorie: Playing?

John: In.

Marjorie: Yes.

John: Well

Marjorie: You're

John: You can

Marjorie: Gonna

John: Have

Marjorie: Have

John: To

Marjorie: To

John: Pull

Marjorie: Pull them

John: Them

Marjorie: Apart.

John: Apart first

Marjorie: He has.

John: And that's going to take energy. That's gonna cost you energy

Marjorie: You

John: To do

Marjorie: Do?

John: That.

Marjorie: Yeah, we gonna get

John: That's going

Marjorie: That

John: To cool

Marjorie: From

John: Things

Marjorie: Things

John: Down.

Marjorie: Down. Yes,

John: Yes it

Marjorie: It

John: Is.

Marjorie: Is.

John: Yeah.

Marjorie: Yeah,

John: Because

Marjorie: Because

John: Gonna

Marjorie: Gonna

John: Use

Marjorie: Use

John: The

Marjorie: The

John: Energy

Marjorie: Energy

John: Up.

Marjorie: Up in

John: Yes.

Marjorie: The process

John: Yes,

Marjorie: Of melting

John: That's it.

Marjorie: It.

John: Exactly.

Marjorie: Exactly.

John: Bingo.

Marjorie: Bingo. OK.

John: Well said.

Marjorie: And suddenly it all makes sense.

John: Well, this podcast is one point of view. There's videos. There's the textbook. There's your instructor. There's your classmates. There's yourself.

Marjorie: I'm just glad I asked for this office hour because I would have had trouble all by myself and I hope I can retain it so I do good on the test.

John: All right, so

Marjorie: So. Well,

John: Well, here's

Marjorie: Here's

John: The

Marjorie: The

John: Test.

Marjorie: Test.

John: Ready?

Marjorie: Oh, no,

John: I one.

Marjorie: I don't want to test. No, no.

John: Sorry.

Marjorie: What if I forget it all? If

John: Well, the

Marjorie: The

John: Test

Marjorie: Test

John: Is

Marjorie: Is

John: Formative.

Marjorie: Formatted

John: It's

Marjorie: There

John: There to

Marjorie: To

John: Help

Marjorie: Help

John: You

Marjorie: You learn?

John: Learn. Not

Marjorie: Oh,

John: Just it's

Marjorie: It's

John: Not

Marjorie: Not

John: To

Marjorie: To

John: See

Marjorie: See

John: What

Marjorie: What

John: You've

Marjorie: You've

John: Learned.

Marjorie: Learned.

John: It's

Marjorie: It's

John: There

Marjorie: There

John: To

Marjorie: To

John: Help

Marjorie: Help

John: You

Marjorie: You

John: Learn

Marjorie: Learn

John: It.

Marjorie: It. OK.

John: Ok,

Marjorie: Do we

John: You

Marjorie: Have

John: Ready

Marjorie: To have

John: To

Marjorie: The

John: Do

Marjorie: Death?

John: This?

Marjorie: I'll be

John: Yep.

Marjorie: Embarrassed

John: Yep,

Marjorie: In

John: We

Marjorie: Front

John: Got

Marjorie: Of

John: It.

Marjorie: All your

John: Ok,

Marjorie: Students.

John: So

Marjorie: Ok.

John: I'm going

Marjorie: Repeat

John: To paint

Marjorie: The

John: A scenario

Marjorie: Scenario

John: For

Marjorie: For

John: You.

Marjorie: You. All right,

John: Everyone

Marjorie: Everyone, get

John: Got your

Marjorie: Your

John: Attention.

Marjorie: Attention. Yes.

John: Yes.

Marjorie: Ok.

John: Ok, here's

Marjorie: Here's

John: The

Marjorie: The

John: Scenario.

Marjorie: Scenario.

John: We're going to add a bunch of salt to the ice

Marjorie: Oh,

John: Water.

Marjorie: No

John: Salt.

Marjorie: Salt.

John: Salt dissolving in the liquid water

Marjorie: That

John: Changes.

Marjorie: Changes things

John: Very

Marjorie: Very much

John: Much so.

Marjorie: That.

John: Now you'll notice the salt doesn't go into the ice.

Marjorie: No,

John: Stir

Marjorie: Stir it

John: It up.

Marjorie: Up. Goes

John: The

Marjorie: Into

John: Salt

Marjorie: The water.

John: Will. The sodium chloride ions will be in the liquid water

Marjorie: Yes.

John: First before your exam questions.

Marjorie: Yes.

John: It's important we understand what's happening at the molecular level. When salt dissolves in water. And I like to think that by analogy. It's like what happens when you pour a box full of heavy wooden marbles into a swimming pool. You still have the marbles, but you'll find they're all dispersed throughout the water, especially as you stir the water as you mix it up. Right. Likewise, add salt to water and all the sodium and

chloride ions disperse throughout the water. You still have sodium ions and chloride ions. They're there and they occupy space. But you'll find they're all dispersed throughout the water, especially upon stirring the water. So that's the model to keep in mind when you think about salt dissolving in water. Got that ready.

Marjorie: All right.

John: Here's the test.

Marjorie: I don't want to test.

John: Think about what's happening at the interface. What have you

Marjorie: You've

John: Done

Marjorie: Done

John: To the

Marjorie: A great.

John: Rate of molecules going from left to right versus right

Marjorie: I

John: To left?

Marjorie: Think if you have added

John: That's

Marjorie: Salt, you have

John: Messed

Marjorie: Messed

John: Up.

Marjorie: Up the process.

John: Let me ask you about the number of water molecules. Liquid water molecules that are now in contact with the ice cube

Marjorie: Yes. Yes.

John: More or less.

Marjorie: Well, the salt has a melting.

John: No,

Marjorie: No,

John: No,

Marjorie: No.

John: Forget that.

Marjorie: Ok.

John: Just

Marjorie: Just

John: Think

Marjorie: Think.

John: Of the water molecules now mixed in with sodium ions and chloride ions. How many water molecules are now in contact with the surface of the ice? More or less. How about another analogy? Let's say you're holding 60 marbles in your hand. How many marbles are in contact with your hand?

Marjorie: 60.

John: 60. All

Marjorie: Right.

John: Right. Now, let's say you're holding 30 marbles in 30 rocks of the same size. How many marbles and contact your hand. Thirty. Thirty. Yeah. You see the rocks occupy space.

Marjorie: Course they do.

John: Yeah. And that means you have less marbles now in contact with your hand. The point is when you have the sodium chloride in there, that makes it so. There are now fewer water molecules in contact with the surface of the ice.

Marjorie: Because as

John: Sodium.

Marjorie: Sodium takes up space.

John: Yes. What's that do to the rate at which water molecules are able to go into the solid phase? Since you have fewer of them

Marjorie: Yeah, that's

John: At the

Marjorie: The

John: Door,

Marjorie: Door.

John: Fewer molecules now are available to go into the department store, to go into the solid phase. There are fewer water molecules now going into the solid phase.

Marjorie: Then the solid phase is going to start diminishing.

John: The solid face, however, has the same number of water molecules exiting the department

Marjorie: So

John: Store

Marjorie: It's going to get smaller.

John: In smaller and smaller and smaller.

Marjorie: Yeah.

John: You have upset the rate. All you've done is upset the rate at which water molecules go in.

Marjorie: Ok. My problem was trying to figure what difference it made that the salt came in. I was thinking if the salt dissolved, it didn't take up space anymore.

John: It

Marjorie: But

John: Does.

Marjorie: Actually

John: It

Marjorie: It does

John: Does.

Marjorie: Take

John: Yes.

Marjorie: Up space. But once you say that, no, it continues to take up space and it's just more in a dissolve state, but it still

John: It's

Marjorie: Continues

John: Still there.

Marjorie: To take up space.

John: Those particles

Marjorie: Therefore,

John: Are still there.

Marjorie: There

John: There

Marjorie: Are

John: Are

Marjorie: Fewer

John: Fewer

Marjorie: To

John: To enter.

Marjorie: Enter,

John: Yes,

Marjorie: But of the

John: The same

Marjorie: Same amount

John: Amount as

Marjorie: Is exiting.

John: Ex-city. Yes.

Marjorie: Gut.

John: Yes.

Marjorie: The ice is going

John: Ice.

Marjorie: To melt to.

John: That's how salt that

Marjorie: That was very

John: Melts

Marjorie: Difficult.

John: Ice. But you did it

Marjorie: Because it's really relatively

John: Simple

Marjorie: Simple once

John: Once

Marjorie: You

John: You see

Marjorie: See

John: The

Marjorie: The

John: Picture

Marjorie: Picture

John: In

Marjorie: In

John: Your

Marjorie: Your.

John: Mind. All right. Next up, an application of our we've been talking about is with the density of water. What do we mean by density?

Marjorie: What do we mean by debt densities, how thick it is?

John: That's the mass per volume. Gold, you understand, is more dense than Styrofoam. Yes.

Marjorie: Yes.

John: Yeah. So if you had a cubic meter of gold and a cubic meter of Styrofoam,

Marjorie: A

John: A

Marjorie: Foot

John: Foot is

Marjorie: Is

John: A

Marjorie: A foot

John: Foot is

Marjorie: Is

John: A

Marjorie: A

John: Foot.

Marjorie: Foot.

John: Yeah.

Marjorie: Right.

John: So the

Marjorie: Okay.

John: Volume

Marjorie: You okay?

John: Is

Marjorie: The

John: The same.

Marjorie: Same. You

John: You have

Marjorie: Have

John: The

Marjorie: The

John: Same

Marjorie: Same

John: Volume

Marjorie: Volume

John: Of

Marjorie: Of gold.

John: Gold

Marjorie: Right.

John: As you have Styrofoam. Right. Right. A cubic meter.

Marjorie: Yes.

John: Yes. Yes.

Marjorie: Yes,

John: So

Marjorie: Sir. But one will be

John: More

Marjorie: More

John: Dense

Marjorie: Dense

John: Than

Marjorie: Than the other.

John: The gold we know is more dense. So you put the two on a scale which reads higher. The

Marjorie: The

John: Gold

Marjorie: Gold would remind

John: Fit

Marjorie: A

John: A lot

Marjorie: Lot

John: More.

Marjorie: More. Yeah.

John: Yes. So within that volume, you've got a lot more mass.

Marjorie: Yeah. Yeah.

John: So we say it's more dense because there's more mass. Yeah.

Marjorie: Yeah,

John: Pavilion.

Marjorie: For volume. Yeah.

John: Yeah. Right.

Marjorie: Right. Yeah.

John: Yeah. Even

Marjorie: You know,

John: Though

Marjorie: This

John: This volume

Marjorie: Volume,

John: Same

Marjorie: Same.

John: The masses are going to be

Marjorie: I

John: Different.

Marjorie: Know it is still acute. It's still a cube. So

John: So

Marjorie: That

John: When

Marjorie: When

John: We

Marjorie: We talk

John: Talk about

Marjorie: About you get

John: A lot

Marjorie: A lot

John: More

Marjorie: More gold

John: Gold in

Marjorie: In there

John: The.

Marjorie: Than you do the other

John: Correct.

Marjorie: Wreck because

John: Because gold

Marjorie: Gold

John: Is

Marjorie: Is

John: More

Marjorie: More dense

John: Dense.

Marjorie: Like.

John: So here's the thing. The density of water changes relative to temperature. Yeah. Remember we talked about ice. Well here we go. Ice when it forms liquid water, transforms into ice and puckers up. It's volume increases because of the crystal and structure.

Marjorie: Yes.

John: Now that means you have the same number of water molecules, but the volume is suddenly bigger. Yes. So that has the effect of making the density lower.

Marjorie: Yeah. Would

John: You've

Marjorie: You?

John: Got a lot of volume, but less mass in that volume.

Marjorie: Yeah, you would. In other words, if you have a cubic foot of water, it will not make a cubic foot of ice. It might make

John: More

Marjorie: That

John: Than a

Marjorie: A

John: Cubic

Marjorie: Cubic

John: Foot.

Marjorie: Foot. Absolutely.

John: Right? Yes. So the masses the same, but the volume is greater, so the density is down.

Marjorie: Here

John: Is

Marjorie: Is

John: To

Marjorie: To say.

John: Say ice cubes are less dense than water, which is why you talked about this before. What does an ice cube do when you throw it into water?

Marjorie: It floats.

John: It

Marjorie: It

John: Floats.

Marjorie: Floats.

John: It.

Marjorie: It's

John: It

Marjorie: Because

John: Floats.

Marjorie: It's not just dense,

John: It's not

Marjorie: Not

John: As

Marjorie: As

John: Dense.

Marjorie: Dense. Right.

John: That's

Marjorie: That's it.

John: It.

Marjorie: Buoyant,

John: Excellent.

Marjorie: More buoyant.

John: Yeah. So now we understand that solid water is less dense than actually it's significantly less dense than liquid water. But what we're going to do here is talk about the density of liquid water. It's an interesting

Marjorie: Okay.

John: Profile.

Marjorie: Proof.

John: Let's say you have water at 1 degree Celsius. That would be what? Thirty four degrees Fahrenheit. And it's all liquid. You don't

Marjorie: See?

John: See any ice cubes in there at all. Pretty cold water. Here's the deal at a micro, micro microscopic level. Interestingly enough, there are still tiny micro crystals in there. And those micro crystals of

Marjorie: Vice.

John: Ice, they

Marjorie: To.

John: Tend to increase the volume of the water

Marjorie: Water

John: Because they're there.

Marjorie: Fountains sit up.

John: Yeah.

Marjorie: Yeah.

John: Good way to think of it. How about warming it up to two degrees Celsius?

Marjorie: You

John: Now.

Marjorie: Will have less of those crystals.

John: How about three degrees Celsius?

Marjorie: Well, pretty soon they're going to be gone

John: And pretty

Marjorie: Pretty.

John: Soon they're gonna be gone. You know what? They're gone at about eight or 9 or 10 degrees Celsius.

Marjorie: Oh, really?

John: Yeah.

Marjorie: Ok.

John: So

Marjorie: So.

John: As you warm up that liquid water,

Marjorie: Yes.

John: The number of micro crystals you have in there decreases.

Marjorie: Decreases

John: What

Marjorie: What happened.

John: Happens to the volume of the water itself as you get fewer and fewer tiny micro ice cubes in there?

Marjorie: Then it would condense.

John: It

Marjorie: It gets

John: Gets more

Marjorie: More

John: Dense.

Marjorie: Dense. Yeah,

John: That's

Marjorie: That's

John: Right.

Marjorie: Right.

John: All right. So that's one trend to keep in mind.

Marjorie: Might

John: Got that.

Marjorie: As

John: As

Marjorie: You

John: You warm

Marjorie: Warm

John: It

Marjorie: It up.

John: Up, you get fewer and fewer micro crystals. And so the density increases. There's another trend that goes along with this. It's called the thermal expansion

Marjorie: Ok.

John: As

Marjorie: As

John: You

Marjorie: You

John: Warms

Marjorie: Warm

John: Something

Marjorie: Something,

John: Up.

Marjorie: Oh,

John: In fact, as you

Marjorie: You

John: Warm

Marjorie: Warm

John: Anything up,

Marjorie: It,

John: The atoms

Marjorie: Some

John: And

Marjorie: Molecules

John: Molecules

Marjorie: Start

John: Start moving

Marjorie: Moving

John: Faster

Marjorie: Fast and

John: And faster.

Marjorie: Fast. Yeah.

John: They have a tendency

Marjorie: I did see

John: To

Marjorie: Two.

John: Expand

Marjorie: Yeah, they run

John: Around

Marjorie: Around

John: Again.

Marjorie: Again.

John: It's like very reason why wires across telephone poles on a warm day, they'll sag more than

Marjorie: But they

John: During a cold

Marjorie: Still

John: Day.

Marjorie: Rate during the cold day,

John: They're

Marjorie: They're

John: Expanding.

Marjorie: Expanding.

John: Yeah.

Marjorie: Yeah.

John: So water as material when you add heat to it because it makes the water molecules move faster. That makes the water want to expand. So we have two opposing trends here.

Marjorie: The

John: The first

Marjorie: First

John: Trend

Marjorie: Truth

John: Is

Marjorie: Is

John: That

Marjorie: That.

John: The water's going to get more compact

Marjorie: One

John: As you

Marjorie: Minute

John: Warming up because

Marjorie: It's.

John: You have fewer and fewer micro crystals. The second trend is as you warm it up, it tends to increase its volume because

Marjorie: There's.

John: Of the thermal expansion. You put those two together and what we find. Is that water has its lowest volume at four degrees Celsius.

Marjorie: Oh, because after that, it begins expanding.

John: The thermal expansion begins to become more important than the disappearing micro crystals.

Marjorie: Right.

John: So we find waters this densest at four degrees Celsius.

Marjorie: Ok.

John: And that has huge consequences.

Marjorie: Tell me about it.

John: Puns will always freeze from the top down. And

Marjorie: I

John: It's

Marjorie: Know it doesn't because I've seen it.

John: Yeah. Let's explain how so.

Marjorie: Well, first you get this thin film of ice and it's on the top, it's

John: But

Marjorie: Not

John: Why

Marjorie: On

John: Is

Marjorie: The

John: That?

Marjorie: Bottom.

John: Why

Marjorie: Is

John: Is

Marjorie: It

John: It on

Marjorie: On the

John: The

Marjorie: Top?

John: Top and not on the bottom? Let's start with the temperature of the air. It's in the wintertime. What's

Marjorie: Ok.

John: The what's

Marjorie: What's

John: The

Marjorie: The

John: Temperature

Marjorie: Temperature

John: Of the

Marjorie: Here?

John: Air? Let's

Marjorie: It's going to be four degrees Celsius.

John: No, let's let's let's

Marjorie: That's

John: Do

Marjorie: Due.

John: A cold January day in New England and let's say it's minus 10 degrees Celsius.

Marjorie: Oh,

John: It's really

Marjorie: Really?

John: Cold

Marjorie: That's

John: Out.

Marjorie: Very cold.

John: It's very

Marjorie: Record.

John: Cold. So there you are. A water molecule, a bunch of water molecules on

Marjorie: On the

John: The surface

Marjorie: Surface

John: Of

Marjorie: Of

John: That

Marjorie: That pond,

John: Pond.

Marjorie: You would think you'd run a huddle together.

John: It

Marjorie: It was

John: Was a

Marjorie: A cold

John: Cold

Marjorie: Snap.

John: Snap. Suddenly

Marjorie: Yes.

John: Your liquid at this point, but

Marjorie: Suddenly

John: Suddenly the

Marjorie: The year

John: Air around

Marjorie: Around.

John: You is minus 10, 15

Marjorie: Degree.

John: Degrees

Marjorie: My

John: Celsius.

Marjorie: Goodness. Yes.

John: You

Marjorie: You

John: Start

Marjorie: Start

John: To

Marjorie: To

John: Cool

Marjorie: Cool

John: Down,

Marjorie: Down.

John: Don't you?

Marjorie: Yes, you do.

John: You

Marjorie: You

John: Do.

Marjorie: Do.

John: So you're going to cool from, say, 10 degrees to 8 degrees to

Marjorie: Yes,

John: 7

Marjorie: As in

John: Degrees.

Marjorie: Degrees, you're

John: You're cooling

Marjorie: Cooling down.

John: Down

Marjorie: Yes

John: Towards

Marjorie: Or zero?

John: Zero, right?

Marjorie: Yes,

John: Then

Marjorie: In years.

John: You're six degrees and then you're four

Marjorie: Or

John: Degrees.

Marjorie: Degree.

John: And then before you get to zero, you're going to have to become four degrees Celsius. Eventually the water at the surface is going to be four degrees Celsius. Why? Because it's getting cooled down by the frigid air.

Marjorie: Yeah.

John: The moment that that water at the surface becomes four degrees Celsius

Marjorie: Becomes denser,

John: Dense, it

Marjorie: It

John: Becomes

Marjorie: Becomes

John: The

Marjorie: The

John: Densest

Marjorie: Densest,

John: It

Marjorie: Densest.

John: Can be. What's

Marjorie: What's it?

John: It do next?

Marjorie: Friezes.

John: Friezes. No,

Marjorie: No.

John: It's still liquid, it's 4 degrees Celsius, it's really dense.

Marjorie: Well,

John: Well,

Marjorie: What's

John: What's

Marjorie: It

John: A do

Marjorie: Do? I should

John: You think

Marjorie: Think

John: Would

Marjorie: We'd

John: Start

Marjorie: Start

John: Forming

Marjorie: Forming crystals.

John: Crystals? No, that's not going to happen till it's zero degrees Celsius. You're a blob of four degree water at the surface of this pond, of this

Marjorie: Well,

John: Liquid

Marjorie: It's

John: Pond. What are you gonna do?

Marjorie: It's

John: It's

Marjorie: Going

John: Gonna

Marjorie: To

John: Shrink.

Marjorie: Shrink.

John: Well, it's it's contracted. Yes, it has. And now it's dense. Now, after you have this dense blob of four degree water.

Marjorie: Yes.

John: What's it gonna do, float up into the air? Noah's going to

Marjorie: Stay

John: Stay in

Marjorie: In

John: The

Marjorie: The

John: Pond

Marjorie: Park. Yeah,

John: At

Marjorie: That's.

John: The surface of the pond. Meanwhile, it's 10 degrees down below.

Marjorie: Well,

John: Well,

Marjorie: Down

John: Down

Marjorie: Below,

John: Below

Marjorie: It's

John: It's

Marjorie: Warmer.

John: Warm because it hasn't been exposed to the

Marjorie: That's right.

John: Frigid

Marjorie: Virginia

John: Air

Marjorie: Area.

John: Yet.

Marjorie: That's

John: Right.

Marjorie: Right.

John: Yeah.

Marjorie: So

John: So

Marjorie: Then

John: Down

Marjorie: Down below,

John: Below. We'll

Marjorie: We'll

John: Start

Marjorie: Start

John: To

Marjorie: To

John: Cool.

Marjorie: Cool. Not

John: Not

Marjorie: Yet.

John: Yet. Well,

Marjorie: Well,

John: It's

Marjorie: It's

John: It's

Marjorie: Still

John: Still the

Marjorie: Away

John: Way from

Marjorie: From

John: The

Marjorie: The

John: Air.

Marjorie: Air. I know. But as the water at the top of it gets colder

John: Down

Marjorie: And

John: To four

Marjorie: Denser.

John: Degrees,

Marjorie: Yes.

John: Denser at 4 degrees, you're telling me the water. That blob of water is most dense.

Marjorie: Yes,

John: Yes.

Marjorie: It is.

John: What happens when you take something that's really dense and

Marjorie: It

John: You

Marjorie: Shrinks.

John: Put in water? Does it float or does it sink?

Marjorie: It

John: Sinks.

Marjorie: Sinks.

John: It sinks. So you're telling me that that blob of water at four degrees Celsius is not going to stay at the surface?

Marjorie: Well, if it goes down to the bottom, it's going to make the bottom cold or to.

John: As it goes down to the bottom,

Marjorie: And then is replaced

John: Please,

Marjorie: By

John: Other

Marjorie: Other

John: Stuff,

Marjorie: Stuff at the top.

John: Ok? Water from the surface is going down to the bottom,

Marjorie: Yes.

John: Right?

Marjorie: Right.

John: What's the water down at the bottom going to do?

Marjorie: Shiver.

John: Shiver. It's

Marjorie: It's

John: Going

Marjorie: Going to

John: To go

Marjorie: Go

John: Up

Marjorie: Up.

John: Because now

Marjorie: Now

John: You

Marjorie: We

John: Have

Marjorie: Have.

John: Water that's four degrees at the bottom.

Marjorie: Right. Because it's denser.

John: It's the densest. Water always sinks to the bottom,

Marjorie: And so it

John: Which

Marjorie: Pushes

John: Is the

Marjorie: The

John: Bottom.

Marjorie: Bottom one

John: He

Marjorie: Further up.

John: Takes

Marjorie: But

John: The

Marjorie: Then

John: Bottom.

Marjorie: When it push

John: Water

Marjorie: It, it's

John: Gets

Marjorie: Almost

John: To

Marjorie: Like

John: Reverse

Marjorie: Reverse boiling.

John: It.

Marjorie: Actually, it's.

John: If you create these little currents, vertical currents.

Marjorie: You rate.

John: So back up. We have frigid air and that frigid air cools the blob of water at the surface from 10 degrees to 7 to 6

Marjorie: Survived.

John: To 5 to 4 degrees. It gets to 4 degrees. And before it gets any cooler,

Marjorie: And

John: It

Marjorie: It

John: Sinks

Marjorie: Sinks. It does

John: It

Marjorie: Sinks

John: Sinks to

Marjorie: To

John: The

Marjorie: The

John: Bottom

Marjorie: Bottom

John: Of

Marjorie: Of

John: The

Marjorie: The

John: Pond,

Marjorie: Pond.

John: Displacing the water at the bottom of the pond, which rises to the surface. So now at the surface, you now have 10 degree water again. What happens to that 10 degree water now?

Marjorie: It begins to lose its heat.

John: And it goes from 10, 9, 8, 7.

Marjorie: And

John: Then

Marjorie: Then

John: It it gets

Marjorie: Pretty

John: To

Marjorie: Soon he gets to four.

John: A 4. Then

Marjorie: Then

John: What happens

Marjorie: It goes, boom, boom,

John: If

Marjorie: Boom, boom.

John: It sinks? Right.

Marjorie: Right.

John: But there's already four degree water beneath it.

Marjorie: I know. So begins

John: Right.

Marjorie: A layer of the four degree water and

John: Yeah.

Marjorie: You keep

John: Yeah.

Marjorie: Pushing where it

John: And

Marjorie: Hasn't

John: Then.

Marjorie: Frozen yet, but it's dense.

John: So

Marjorie: So

John: Can

Marjorie: It's

John: You

Marjorie: Still

John: See

Marjorie: Water.

John: How

Marjorie: But

John: It

Marjorie: It's not

John: Is

Marjorie: Ice. It's

John: That

Marjorie: Dense.

John: Eventually the

Marjorie: Yes,

John: Entire

Marjorie: I hope.

John: Pond will become four degrees Celsius?

Marjorie: Yes, that's right.

John: And how it is that that surface water can't get can it just can not get any colder than four degrees Celsius until the

Marjorie: The

John: Entire

Marjorie: Entire

John: Pond itself

Marjorie: 4

John: Is 4

Marjorie: Degrees

John: Degrees

Marjorie: Celsius.

John: Celsius.

Marjorie: And

John: And

Marjorie: Then

John: Then

Marjorie: Where's

John: Where's

Marjorie: There

John: Effort?

Marjorie: For it to sink,

John: So

Marjorie: So.

John: Eventually because the water's densest at four degrees Celsius. It's

Marjorie: It's.

John: Always just going to sink to the bottom in the warmer, but water underneath. It's going to rise to the surface

Marjorie: Surfaced.

John: To cool down

Marjorie: Down

John: That that

Marjorie: To post

John: Process

Marjorie: °c

John: Is going to

Marjorie: Go

John: Go round

Marjorie: Round

John: And

Marjorie: And

John: Round

Marjorie: Round

John: And

Marjorie: And

John: Round

Marjorie: Round

John: Until

Marjorie: Until.

John: The entire pond is 4 degrees Celsius.

Marjorie: Oh,

John: And

Marjorie: And

John: Only then

Marjorie: There's no place for it to go,

John: Would

Marjorie: So

John: Have

Marjorie: It has to

John: To

Marjorie: Stay

John: Stay there.

Marjorie: There and

John: And

Marjorie: Get colder.

John: Only then will the surface go from four degrees to three degrees.

Marjorie: Yeah. And from three degrees to two degrees and two degrees

John: To

Marjorie: To zero

John: Use

Marjorie: Degrees.

John: To

Marjorie: Ice,

John: Ice.

Marjorie: Ice.

John: Bam.

Marjorie: Get your skates.

John: Yeah. Now, here's an interesting think if you have a lake that's really, really deep.

Marjorie: Yes.

John: Yes. Oh,

Marjorie: Oh.

John: It will never freeze over.

Marjorie: Is that my is still soft in the middle and you can go through.

John: Safer to skate by the edge of a pond than

Marjorie: Yeah, it sure

John: In the

Marjorie: Is.

John: Middle. Great.

Marjorie: Oh, I do remember that crack. Oh, my. Yes.

John: So

Marjorie: Oh,

John: If

Marjorie: If

John: You

Marjorie: You

John: Have

Marjorie: Have

John: A really

Marjorie: Really

John: Deep

Marjorie: Deep

John: Pond

Marjorie: Pond

John: Or

Marjorie: Or lake,

John: Lake,

Marjorie: You'll

John: You'll

Marjorie: Find

John: Find it

Marjorie: It

John: Won't

Marjorie: Won't

John: Freeze

Marjorie: Free zone.

John: Over

Marjorie: That's

John: It

Marjorie: Right.

John: Because

Marjorie: Because

John: You

Marjorie: You have

John: Have to

Marjorie: To

John: Get

Marjorie: Get

John: That

Marjorie: That entire

John: Entire

Marjorie: Pool

John: Ponder

Marjorie: Under Lee

John: Lake

Marjorie: Least

John: To

Marjorie: Four

John: Four degrees

Marjorie: Degrees Celsius.

John: Celsius

Marjorie: Yeah.

John: In

Marjorie: And

John: Winters

Marjorie: Winter's

John: Just

Marjorie: Just

John: Typically

Marjorie: Typically

John: Aren't

Marjorie: Aren't long

John: Long

Marjorie: Enough.

John: Enough in temperate

Marjorie: Well

John: Regions.

Marjorie: Sometimes

John: Sometimes it

Marjorie: It does.

John: Does

Marjorie: Well the pond

John: A

Marjorie: Is

John: Small

Marjorie: Small enough. The whole

John: Thing.

Marjorie: Thing does

John: Yep.

Marjorie: Freeze over.

John: Yep.

Marjorie: Yeah.

John: So

Marjorie: And then

John: You

Marjorie: You

John: Can

Marjorie: Can go

John: Go skating?

Marjorie: Skating.

John: Yeah.

Marjorie: Yeah.

John: So

Marjorie: So that's

John: That's how

Marjorie: How it

John: It is.

Marjorie: Is.

John: Ponds

Marjorie: Ponds

John: Will

Marjorie: Will always

John: Always freeze

Marjorie: Freeze

John: From

Marjorie: From

John: The

Marjorie: The top.

John: Top down.

Marjorie: I

John: I think

Marjorie: Think

John: That's

Marjorie: That's

John: One

Marjorie: Wonderful.

John: That's

Marjorie: That's

John: Good

Marjorie: Good for

John: For aquatic

Marjorie: Aquatic

John: Life.

Marjorie: Life because

John: Because that

Marjorie: That

John: Layer

Marjorie: Layer and

John: Of

Marjorie: Lately

John: Ice that

Marjorie: The

John: Forms

Marjorie: Fish can

John: Still

Marjorie: Still swim.

John: Swim. It

Marjorie: It will

John: Will

Marjorie: Insulate

John: Insulate them

Marjorie: Them

John: From

Marjorie: From. Yes,

John: The colder

Marjorie: It does.

John: Weather

Marjorie: It

John: Above.

Marjorie: Does. It does.

John: Yeah.

Marjorie: It does.

John: That's

Marjorie: That's

John: Wonderful.

Marjorie: Wonderful.

John: Yeah.

Marjorie: Yeah. Excellent.

John: Excellent.

Marjorie: We

John: We

Marjorie: Have

John: Have some

Marjorie: Some

John: Properties

Marjorie: Properties

John: Of

Marjorie: Of

John: Water

Marjorie: Water

John: To

Marjorie: To

John: Talk

Marjorie: Talk

John: About

Marjorie: About

John: Here

Marjorie: Here

John: In

Marjorie: In

John: The

Marjorie: The

John: Next

Marjorie: Next

John: Section.

Marjorie: Section. Okay.

John: Surface

Marjorie: Surface

John: Tension

Marjorie: Tension

John: Is

Marjorie: Is

John: One

Marjorie: One

John: Of

Marjorie: Of

John: Them.

Marjorie: Them.

John: What

Marjorie: What

John: Else

Marjorie: Else

John: Do

Marjorie: Do

John: We

Marjorie: We

John: Have

Marjorie: Have

John: Here?

Marjorie: Here?

John: Capillary

Marjorie: Capillary

John: Action.

Marjorie: Action, right?

John: All right.

Marjorie: Surface

John: Surface tension

Marjorie: Tension

John: In

Marjorie: In

John: Capillary

Marjorie: Capillary

John: Action.

Marjorie: Action.

John: So

Marjorie: So

John: Invision,

Marjorie: Just

John: Just some

Marjorie: Some

John: Liquid

Marjorie: Liquid

John: Water

Marjorie: Water. Yes,

John: And

Marjorie: We're

John: We're at

Marjorie: At

John: The

Marjorie: The surface

John: Surface of

Marjorie: Of that

John: That

Marjorie: Liquid

John: Liquid

Marjorie: Water

John: Water and

Marjorie: And above

John: Above

Marjorie: That

John: That

Marjorie: Liquid

John: Liquid water.

Marjorie: Water just

John: Just

Marjorie: To get

John: Get

Marjorie: Air

John: Air.

Marjorie: Right now.

John: Now consider

Marjorie: Consider

John: Yourself

Marjorie: Yourself

John: To

Marjorie: To

John: Be

Marjorie: Be

John: A

Marjorie: A water

John: Water

Marjorie: Molecule

John: Molecule

Marjorie: On

John: On the

Marjorie: The surface.

John: Surface. You

Marjorie: You

John: Look

Marjorie: Look

John: Around

Marjorie: Around

John: You

Marjorie: You

John: And

Marjorie: And

John: Underneath

Marjorie: Underneath you,

John: You you've

Marjorie: You've got

John: Got water

Marjorie: Water molecules

John: Molecules

Marjorie: Pull

John: Pulling

Marjorie: You.

John: On you,

Marjorie: Yes,

John: But

Marjorie: But you

John: You look

Marjorie: Look

John: Above

Marjorie: Above you.

John: You and

Marjorie: There

John: There

Marjorie: Are

John: Are

Marjorie: No

John: No

Marjorie: Water

John: Water

Marjorie: Molecules.

John: Molecules.

Marjorie: No.

John: You've

Marjorie: You've

John: Only

Marjorie: Only got

John: Got

Marjorie: Water

John: Water

Marjorie: Molecules

John: Molecules

Marjorie: From

John: From the

Marjorie: The

John: Side

Marjorie: Side

John: And

Marjorie: From

John: From

Marjorie: Underneath.

John: Underneath.

Marjorie: And

John: And you

Marjorie: You

John: Stick

Marjorie: Stick to

John: To the

Marjorie: The ones

John: Ones

Marjorie: To

John: To

Marjorie: The

John: The

Marjorie: Side

John: Side.

Marjorie: And underneath. But you can stick to what's above you.

John: Yeah, there's

Marjorie: There's something

John: Something different

Marjorie: Different that's

John: That's going

Marjorie: Going

John: On.

Marjorie: On. OK.

John: So

Marjorie: So consider

John: Consider now

Marjorie: Now you

John: You have

Marjorie: Have a

John: A pin

Marjorie: Pin

John: And

Marjorie: And you

John: You

Marjorie: Want

John: Want to

Marjorie: To poke

John: Poke the

Marjorie: The pin

John: Pin into

Marjorie: Into the

John: The

Marjorie: Water.

John: Water

Marjorie: Yeah. As

John: As

Marjorie: The

John: The pin

Marjorie: Tin

John: Goes

Marjorie: Goes into

John: Into

Marjorie: The

John: The water.

Marjorie: Water, it

John: It has

Marjorie: Has

John: To

Marjorie: To separate

John: Separate water

Marjorie: Water

John: Molecules

Marjorie: Molecules from

John: From each

Marjorie: Each other

John: Other in

Marjorie: In order

John: Order to

Marjorie: To

John: Get

Marjorie: Get

John: To

Marjorie: To

John: The

Marjorie: The

John: Underneath.

Marjorie: Right because it has to go through them.

John: It

Marjorie: Best

John: Has to

Marjorie: To go

John: Go through

Marjorie: Through

John: Them

Marjorie: This

John: And

Marjorie: And

John: Consider

Marjorie: Consider

John: The

Marjorie: The

John: Water

Marjorie: Water

John: Molecules

Marjorie: Molecules

John: Like

Marjorie: Like all

John: All

Marjorie: Holding

John: Holding hands

Marjorie: Hands. They are they're playing their games.

John: In there,

Marjorie: They're holding

John: Holding

Marjorie: Hands

John: Hands with

Marjorie: With

John: The

Marjorie: The dipole

John: Dipole dipole

Marjorie: Dipole attraction.

John: Attractions.

Marjorie: Yes.

John: And

Marjorie: So

John: So

Marjorie: For

John: For

Marjorie: That

John: That pin

Marjorie: Pin to

John: To

Marjorie: Go

John: Go into

Marjorie: Into

John: The

Marjorie: The water,

John: Water,

Marjorie: It

John: It has

Marjorie: Has

John: To

Marjorie: To

John: Poke

Marjorie: Poke

John: Through

Marjorie: Through

John: And

Marjorie: And

John: And

Marjorie: It actually

John: Actually

Marjorie: Breaks

John: Break some

Marjorie: Some water

John: Water

Marjorie: Molecules

John: Molecules

Marjorie: Apart

John: Apart

Marjorie: From

John: From

Marjorie: Each

John: Each

Marjorie: Other.

John: Other. And they

Marjorie: They don't

John: Don't

Marjorie: Want

John: Want to

Marjorie: To

John: Do

Marjorie: Do

John: That.

Marjorie: That. You should not be able to do that. That's

John: So

Marjorie: Not nice.

John: What happens

Marjorie: Happens is

John: Is the

Marjorie: The surface

John: Surface of

Marjorie: Of the

John: The

Marjorie: Water

John: Water, because

Marjorie: Because of

John: Of all

Marjorie: All

John: The

Marjorie: The attraction

John: Attraction

Marjorie: Among

John: Among

Marjorie: The

John: The

Marjorie: Water

John: Water molecules,

Marjorie: Molecules.

John: Behaves very much like a rubber sheet.

Marjorie: Really?

John: And here's

Marjorie: Here's an

John: An activity

Marjorie: Activity

John: You

Marjorie: You might

John: Might

Marjorie: Have

John: Have

Marjorie: Done.

John: Done. You

Marjorie: You

John: Can

Marjorie: Can take

John: Take

Marjorie: A

John: A

Marjorie: Paper

John: Paper

Marjorie: Clip.

John: Clip

Marjorie: Yeah. And

John: And you

Marjorie: You

John: Can

Marjorie: Can

John: Very

Marjorie: Very carefully,

John: Carefully,

Marjorie: Gently

John: Gently

Marjorie: Lay

John: Lay

Marjorie: It

John: It on

Marjorie: On top

John: Top of

Marjorie: Of some

John: Some.

Marjorie: Still

John: Still water

Marjorie: Water

John: In

Marjorie: In the

John: The

Marjorie: Paper

John: Paper

Marjorie: Clip

John: Clip will

Marjorie: Will float,

John: Not

Marjorie: Not

John: Sink.

Marjorie: Sink. That's the same

John: The same

Marjorie: As

John: Is

Marjorie: Floating.

John: Not

Marjorie: Not really.

John: Really. Oh,

Marjorie: Oh, really?

John: Really? Yeah. Correct.

Marjorie: Correct. My.

John: What it's doing is it's resting. Now if you take a bowling ball and put it on trampoline, would you say the bowling ball is floating on the trampoline?

Marjorie: Course

John: Of course.

Marjorie: Not.

John: No.

Marjorie: No

John: The bowling

Marjorie: Bowling ball

John: Ball is

Marjorie: Is

John: Sitting

Marjorie: Sitting

John: On

Marjorie: On the

John: The trampoline,

Marjorie: Trampoline, pushing

John: Pushing

Marjorie: It

John: It

Marjorie: Down.

John: Down a little

Marjorie: Yes,

John: Bit. Right.

Marjorie: Right. And then it comes back

John: But

Marjorie: Up

John: It's not

Marjorie: Again.

John: Floating

Marjorie: Floating.

John: On

Marjorie: No.

John: The trampoline.

Marjorie: No.

John: Well,

Marjorie: Well,

John: The

Marjorie: The same

John: Same

Marjorie: Thing

John: Thing

Marjorie: Here.

John: Here. That

Marjorie: That

John: Paper

Marjorie: Paper clip

John: Clip is

Marjorie: Is

John: Not

Marjorie: Not floating.

John: Floating. It's

Marjorie: It's

John: Actually

Marjorie: Actually

John: On

Marjorie: On

John: The

Marjorie: The

John: Surface

Marjorie: Surface

John: Of water,

Marjorie: Water

John: Just

Marjorie: Just as

John: As the

Marjorie: A

John: Bowling

Marjorie: Bowling

John: Ball

Marjorie: Ball

John: Is

Marjorie: Is

John: On

Marjorie: On

John: The

Marjorie: The

John: Trampoline.

Marjorie: Trampoline. OK. Right.

John: Right. It's

Marjorie: It's resting

John: Resting on

Marjorie: On

John: The water,

Marjorie: Water. Yeah,

John: But

Marjorie: But

John: It

Marjorie: It has

John: Has weight.

Marjorie: Weight. And

John: And

Marjorie: So

John: So it

Marjorie: It

John: Depresses

Marjorie: Depresses

John: The

Marjorie: The

John: Water

Marjorie: Water down

John: Downward

Marjorie: A

John: A little

Marjorie: Little.

John: Bit

Marjorie: Does

John: Like

Marjorie: The water

John: Water.

Marjorie: Mind

John: It

Marjorie: It.

John: Does

Marjorie: Does

John: It

Marjorie: It.

John: It

Marjorie: It bends

John: Bends down

Marjorie: Down inward.

John: Inward,

Marjorie: Yes.

John: But

Marjorie: And assistance

John: It holds it

Marjorie: It up

John: Up there

Marjorie: There because

John: Because it's

Marjorie: It's

John: Still

Marjorie: Still holding

John: Holding hands.

Marjorie: Hands under water.

John: Yeah.

Marjorie: Yeah. OK.

John: Yeah. If

Marjorie: If

John: It

Marjorie: It

John: Were

Marjorie: Were floating

John: Floating, would

Marjorie: Would be

John: Be like

Marjorie: Like

John: A

Marjorie: A

John: Boat

Marjorie: Boat. It

John: Would

Marjorie: Would be

John: Be partially

Marjorie: It would

John: Submerged.

Marjorie: Merged. It's.

John: It's not

Marjorie: Yes,

John: Submerged

Marjorie: It would.

John: Yet.

Marjorie: Yeah.

John: It's

Marjorie: It's not

John: Not submerged

Marjorie: Submerged.

John: At

Marjorie: Oh,

John: All.

Marjorie: Ok. I understand

John: It's on the

Marjorie: The surface.

John: Surface.

Marjorie: Right. I understand.

John: Yeah. The water.

Marjorie: Wait a minute. Why doesn't it sink?

John: Because

Marjorie: Because

John: All

Marjorie: All the

John: The attractions

Marjorie: Attractions of

John: Of

Marjorie: The

John: A

Marjorie: Water

John: Water

Marjorie: Molecules

John: Molecules free

Marjorie: For each

John: Each

Marjorie: Other.

John: Other

Marjorie: Yes. That

John: Makes

Marjorie: Makes

John: It

Marjorie: It

John: Like

Marjorie: Like a

John: A

Marjorie: Barrier.

John: Barrier, a rubber

Marjorie: Rubber

John: Barrier

Marjorie: Barrier.

John: That's

Marjorie: That's

John: Difficult,

Marjorie: Difficult

John: Relatively speaking, to penetrate.

Marjorie: If

John: If you

Marjorie: Push.

John: Push down on that paperclip, yeah, it will sink for

Marjorie: Right.

John: Sure. But

Marjorie: But if

John: If

Marjorie: You

John: You

Marjorie: Lay

John: Lay it

Marjorie: It

John: Very

Marjorie: Very

John: Carefully

Marjorie: Carefully

John: On

Marjorie: On the

John: The water,

Marjorie: Water, you

John: You

Marjorie: Can

John: Can get

Marjorie: Get it.

John: It to rest on top of the water. In

Marjorie: It's

John: This, an

Marjorie: An activity

John: Activity

Marjorie: You

John: You should

Marjorie: Should

John: All

Marjorie: Try.

John: Try at home if you haven't already.

Marjorie: And

John: And

Marjorie: That's

John: That's how water

Marjorie: Water bugs.

John: Bugs will

Marjorie: We'll

John: Skim across

Marjorie: Skate

John: The surface.

Marjorie: Across it. Oh, I

John: Oh

Marjorie: See.

John: Yeah.

Marjorie: Yes,

John: Yeah,

Marjorie: I've seen

John: Yeah.

Marjorie: Them.

John: The

Marjorie: They we call them skating.

John: Skating. Yeah,

Marjorie: Skating.

John: Skating. But

Marjorie: But

John: It's

Marjorie: It's

John: Not

Marjorie: Not ice.

John: Ice.

Marjorie: It's

John: It's water.

Marjorie: Water.

John: Yeah.

Marjorie: Yeah, they're very

John: Very

Marjorie: Light.

John: Light.

Marjorie: Well, wait a minute. Wait a minute.

John: Yeah.

Marjorie: If. If. Never mind.

John: Keep

Marjorie: Keep

John: Going.

Marjorie: Going. All

John: All

Marjorie: Right.

John: Right. Next

Marjorie: Next,

John: Thing

Marjorie: We're

John: We're

Marjorie: Going

John: Gonna

Marjorie: To look

John: Look

Marjorie: At.

John: At here

Marjorie: Here's

John: Is capillary

Marjorie: Military.

John: Action.

Marjorie: Yeah.

John: And it

Marjorie: Results

John: Results from

Marjorie: From an

John: An

Marjorie: Interplay

John: Interplay

Marjorie: Of

John: Of what

Marjorie: What

John: We

Marjorie: We call

John: Call adhesive and

Marjorie: Cohesive

John: Cohesive

Marjorie: Force.

John: Forces

Marjorie: Really?

John: To.

Marjorie: What's the difference between adding something cohesive?

John: Well, adhesive means it's a

Marjorie: Dipole

John: Dipole

Marjorie: Dipole

John: Dipole

Marjorie: Attraction

John: Attraction

Marjorie: Is

John: Between

Marjorie: Between two

John: Two

Marjorie: Different

John: Different

Marjorie: Materials.

John: Materials.

Marjorie: Yes,

John: Cohesive

Marjorie: Cohesive means

John: Means

Marjorie: It's

John: It's

Marjorie: A

John: A dipole

Marjorie: Dipole

John: Dipole

Marjorie: Dipole attraction

John: Attraction within

Marjorie: Within a

John: A

Marjorie: Material.

John: Material. So

Marjorie: So

John: You

Marjorie: You understand.

John: Understand with

Marjorie: Okay.

John: Liquid

Marjorie: Liquid

John: Water,

Marjorie: Water. OK.

John: You have

Marjorie: Water

John: Water molecules,

Marjorie: Molecules

John: Love

Marjorie: Love water

John: Water

Marjorie: Molecule.

John: Molecules,

Marjorie: Yes.

John: Those

Marjorie: Those we

John: We would

Marjorie: Would

John: Classify

Marjorie: Classify as

John: As cohesive

Marjorie: Cohesive forces

John: Forces between

Marjorie: Between those

John: Those

Marjorie: Water

John: Water

Marjorie: Molecules.

John: Molecules.

Marjorie: Now,

John: Now, water

Marjorie: Water

John: Is

Marjorie: Is

John: Also

Marjorie: Also attracted

John: Attracted to

Marjorie: To glass,

John: Glass, which

Marjorie: Which

John: Is

Marjorie: Is also

John: Also

Marjorie: Why

John: Polar.

Marjorie: It's

John: It's

Marjorie: Made

John: Made of

Marjorie: Of

John: Silicon

Marjorie: Silicon

John: Dioxide,

Marjorie: Dioxide, which

John: Which is

Marjorie: Is a

John: A polar

Marjorie: Polar material.

John: Material.

Marjorie: So

John: So

Marjorie: When

John: When we

Marjorie: We talk

John: Talk

Marjorie: About

John: About

Marjorie: Adhesive

John: Adhesive

Marjorie: Force,

John: Force, we're

Marjorie: We're talking

John: Talking

Marjorie: About

John: About an

Marjorie: An

John: Attraction

Marjorie: Attraction between

John: Between two

Marjorie: Two

John: Different

Marjorie: Different materials.

John: Materials. And a good example

Marjorie: Example would

John: Would

Marjorie: Be

John: Be between

Marjorie: Between

John: Water

Marjorie: Water and

John: And

Marjorie: Glass.

John: Glass. So

Marjorie: So

John: Water

Marjorie: Water will

John: Will adhere

Marjorie: Here

John: To glass.

Marjorie: It does.

John: Water

Marjorie: Water

John: Will

Marjorie: Will

John: Cohere

Marjorie: Cope.

John: To itself. Consider water in a test tube.

Marjorie: If

John: If you

Marjorie: You

John: Look

Marjorie: Look

John: Very

Marjorie: Very

John: Carefully

Marjorie: Carefully

John: From

Marjorie: From

John: The

Marjorie: The side,

John: Side,

Marjorie: Yeah,

John: You'll

Marjorie: You'll

John: See

Marjorie: See

John: The

Marjorie: The

John: Water's

Marjorie: Waters

John: Actually

Marjorie: Actually

John: Creeping

Marjorie: Creeping

John: Up

Marjorie: The

John: The edges

Marjorie: Edges. That

John: Of

Marjorie: Is totally weird.

John: It's

Marjorie: It's

John: Called.

Marjorie: Called

John: You know that term, this

Marjorie: Meniscal

John: Meniscus?

Marjorie: Meniscus.

John: Yeah.

Marjorie: Yeah,

John: For

Marjorie: For the

John: The water

Marjorie: Water

John: Adhering

Marjorie: Hearing

John: To the

Marjorie: Side

John: Sides of

Marjorie: Of

John: The

Marjorie: The

John: Glass.

Marjorie: Glass,

John: What

Marjorie: What

John: Happens

Marjorie: Happens

John: Is

Marjorie: Is

John: It

Marjorie: It

John: Rises

Marjorie: Rises

John: On the edges.

Marjorie: Because

John: It's because

Marjorie: Of

John: Of the adhesion

Marjorie: The

John: Between

Marjorie: Tree.

John: The water and the glass.

Marjorie: But wait

John: Wait a

Marjorie: A

John: Minute.

Marjorie: Minute,

John: Wait

Marjorie: Wait

John: A

Marjorie: A

John: Minute,

Marjorie: Minute,

John: Wait.

Marjorie: Wait a minute.

John: How

Marjorie: How

John: Does

Marjorie: Does it

John: It know?

Marjorie: Know?

John: Why

Marjorie: Why

John: Doesn't

Marjorie: Doesn't

John: It

Marjorie: It

John: Just

Marjorie: Just

John: Adhere

Marjorie: Adhere

John: Where

Marjorie: Where

John: The

Marjorie: The

John: Water

Marjorie: Water

John: Is

Marjorie: Is

John: Put

Marjorie: Put

John: Into

Marjorie: Into

John: It?

Marjorie: It?

John: Why

Marjorie: Why

John: Does

Marjorie: Does

John: It

Marjorie: It

John: Climb

Marjorie: Climb

John: Up?

Marjorie: Up? So

John: Why

Marjorie: Why does

John: Does it

Marjorie: It

John: Go

Marjorie: Go

John: Higher?

Marjorie: Higher?

John: That's

Marjorie: That's

John: What's

Marjorie: What's

John: So

Marjorie: So

John: Weird.

Marjorie: Weird.

John: Oh,

Marjorie: Oh,

John: I

Marjorie: I

John: Get

Marjorie: Get

John: You.

Marjorie: You.

John: Yeah.

Marjorie: Yeah,

John: It

Marjorie: It

John: Actually

Marjorie: Actually

John: Creeps

Marjorie: Creeps

John: Up

Marjorie: Up.

John: The edge.

Marjorie: Why?

John: How

Marjorie: How

John: Can

Marjorie: Can

John: It

Marjorie: It do

John: Do that?

Marjorie: That?

John: Your

Marjorie: You're silent.

John: Silent.

Marjorie: Well, maybe it just it likes it so much that it wants more. I

John: I like

Marjorie: Like

John: That.

Marjorie: That.

John: And

Marjorie: And

John: So

Marjorie: So

John: Therefore,

Marjorie: Therefore,

John: It's

Marjorie: It's

John: A sort

Marjorie: Sort

John: Of

Marjorie: Of

John: Like

Marjorie: Like a

John: Makeover.

Marjorie: Magnet for this.

John: This dress

Marjorie: It's really

John: And

Marjorie: Wonderful.

John: The cookies,

Marjorie: Is

John: The

Marjorie: The

John: Question

Marjorie: Question

John: Really

Marjorie: Really

John: Is

Marjorie: Is

John: Why

Marjorie: Why

John: Does

Marjorie: Does it

John: It keep

Marjorie: Keep

John: Rising

Marjorie: Rising

John: To

Marjorie: To

John: The

Marjorie: The

John: Top,

Marjorie: Mind,

John: Doesn't

Marjorie: Doesn't

John: It?

Marjorie: It, if it

John: It

Marjorie: Wants

John: Wasn't.

Marjorie: It?

John: I

Marjorie: I

John: Think

Marjorie: Think

John: It

Marjorie: It

John: Runs

Marjorie: Runs

John: Out

Marjorie: Out of

John: Good.

Marjorie: Steam.

John: No.

Marjorie: No.

John: Something

Marjorie: Something

John: Good

Marjorie: Good

John: Starts

Marjorie: Starts

John: With

Marjorie: As good

John: Good. Ramsey

Marjorie: A cavity.

John: Haverly Gravity

Marjorie: Gravity.

John: And

Marjorie: Gravity

John: Is

Marjorie: Is

John: Pulling

Marjorie: Pulling

John: It

Marjorie: It

John: Down.

Marjorie: Down.

John: No

Marjorie: No

John: Kidding.

Marjorie: Kidding.

John: Yeah.

Marjorie: Yeah. Well, how

John: I'll

Marjorie: Come

John: Send it

Marjorie: It

John: Over.

Marjorie: Overcame gravity? That makes it pretty strong, doesn't it?

John: They're

Marjorie: They're

John: Strong

Marjorie: Strong

John: Enough

Marjorie: Enough

John: To

Marjorie: To

John: Create

Marjorie: Create

John: What

Marjorie: What

John: We

Marjorie: We

John: Call

Marjorie: Call

John: A meniscus.

Marjorie: Diskettes.

John: So

Marjorie: So

John: The the

Marjorie: The

John: Water

Marjorie: Water

John: Will

Marjorie: Will

John: Rise

Marjorie: Rise

John: Up

Marjorie: At

John: The

Marjorie: The

John: Edge

Marjorie: Edges. And

John: Of

Marjorie: This

John: The glass.

Marjorie: Is the edge, the meniscus,

John: It's the

Marjorie: The

John: Curvature

Marjorie: Curvature

John: Of

Marjorie: Of

John: The

Marjorie: The

John: Water

Marjorie: Water

John: That

Marjorie: That

John: You

Marjorie: You see.

John: See that's

Marjorie: That's

John: Called

Marjorie: Okay.

John: The meniscus.

Marjorie: In other words,

John: It

Marjorie: It

John: Is

Marjorie: Is

John: The

Marjorie: The

John: Edge,

Marjorie: Drain.

John: Right? Yeah.

Marjorie: Yeah. Okay.

John: On the

Marjorie: Surface.

John: Surface

Marjorie: That

John: That explains.

Marjorie: Explains it.

John: Yeah. There's

Marjorie: There's

John: That

Marjorie: The adhesive

John: Piece of forces

Marjorie: Forces

John: Between

Marjorie: Between

John: The

Marjorie: The

John: Water

Marjorie: Water

John: And

Marjorie: And

John: The

Marjorie: The

John: Glass.

Marjorie: Glass.

John: But there's

Marjorie: There's

John: Also

Marjorie: Also

John: Gravity

Marjorie: Gravity pulling

John: Pulling it downward.

Marjorie: The

John: And this the third

Marjorie: Third

John: Force,

Marjorie: Force,

John: Cohesive

Marjorie: Cohesive

John: Force

Marjorie: Force.

John: Between water

Marjorie: What

John: And water. What happens

Marjorie: Happens

John: Is

Marjorie: Is

John: If

Marjorie: Your

John: Your capillary

Marjorie: Capital areas

John: Is narrow

Marjorie: Narrow

John: Enough,

Marjorie: Enough? Is

John: The

Marjorie: The

John: Water

Marjorie: Water

John: Will want

Marjorie: To

John: To form

Marjorie: Form a

John: A ball.

Marjorie: Ball. Really?

John: Yeah.

Marjorie: Yeah.

John: In

Marjorie: In

John: The

Marjorie: The

John: Middle

Marjorie: Middle.

John: It kind

Marjorie: Kind

John: Of

Marjorie: Of

John: Balls

Marjorie: Balls.

John: Up

Marjorie: Really.

John: And. Yeah.

Marjorie: Yeah.

John: It'll

Marjorie: It'll

John: That'll

Marjorie: That'll

John: Actually

Marjorie: Actually

John: Help

Marjorie: Help

John: It

Marjorie: It to

John: To rise.

Marjorie: Rise.

John: Also

Marjorie: Also

John: Put

Marjorie: Put

John: It

Marjorie: It

John: This

Marjorie: This

John: Way

Marjorie: Way

John: You

Marjorie: You

John: Have

Marjorie: Have

John: The

Marjorie: The

John: Water

Marjorie: Water

John: Molecules

Marjorie: Molecules

John: Creeping

Marjorie: Creeping

John: Up

Marjorie: Up

John: The

Marjorie: The

John: Edge.

Marjorie: Edge,

John: Right.

Marjorie: Right. I

John: I guess

Marjorie: Guess so.

John: Those

Marjorie: Those

John: Water

Marjorie: Water

John: Molecules

Marjorie: Molecules

John: That

Marjorie: That

John: Have

Marjorie: Have

John: Just

Marjorie: Just

John: Creeped

Marjorie: Creeped

John: Up

Marjorie: Up

John: The

Marjorie: The

John: Edge,

Marjorie: Edge you're

John: You're going

Marjorie: Gonna

John: To say

Marjorie: Say

John: To

Marjorie: To

John: The

Marjorie: The

John: Other

Marjorie: Other

John: Water

Marjorie: Water

John: Molecules.

Marjorie: Molecules.

John: Hey

Marjorie: Hey

John: Everybody,

Marjorie: Everybody,

John: Come

Marjorie: Come

John: On

Marjorie: On

John: Up

Marjorie: Up

John: Here.

Marjorie: Here. The water's fine

John: And

Marjorie: And

John: They

Marjorie: They

John: Do.

Marjorie: Do.

John: If

Marjorie: If

John: You're

Marjorie: Your

John: Capillary

Marjorie: Capillaries

John: Is narrow

Marjorie: Narrow.

John: Enough

Marjorie: Oh then keep right.

John: Those

Marjorie: Ongoing.

John: They'll keep

Marjorie: Keep

John: On

Marjorie: On

John: Going

Marjorie: Going

John: In

Marjorie: In

John: The

Marjorie: The

John: Cohesive

Marjorie: Coke. Yes.

John: Forces between

Marjorie: Between

John: The

Marjorie: The

John: Water

Marjorie: Water. Well,

John: Actually

Marjorie: Wait a minute.

John: Help

Marjorie: Wait a minute.

John: That matter

Marjorie: But look

John: Cohesive

Marjorie: Cohesive then.

John: And

Marjorie: Then

John: Then overcome

Marjorie: Overcome

John: The

Marjorie: The

John: Gravity

Marjorie: Gravity.

John: Because

Marjorie: Because

John: Of

Marjorie: If

John: The

Marjorie: The

John: Gravity.

Marjorie: Gravity is pulling

John: Yes.

Marjorie: Down,

John: It's

Marjorie: It's

John: Pulling.

Marjorie: Pulling down

John: Yes.

Marjorie: All

John: All the

Marjorie: The

John: Time.

Marjorie: Time.

John: It's

Marjorie: It's

John: Not

Marjorie: Not

John: Pulling

Marjorie: Pulling

John: Down.

Marjorie: Down some

John: Yes.

Marjorie: Time.

John: So but

Marjorie: But

John: Only

Marjorie: Only

John: When

Marjorie: When

John: You

Marjorie: You

John: Have

Marjorie: Have

John: A

Marjorie: A

John: Narrow

Marjorie: Narrow

John: Capillary will it

Marjorie: View

John: Be able to overcome

Marjorie: Of

John: The gravity

Marjorie: Gravity because

John: Because there's

Marjorie: There's

John: Not

Marjorie: Not

John: That

Marjorie: That

John: Much

Marjorie: Much

John: Water.

Marjorie: Water.

John: If

Marjorie: If

John: You

Marjorie: You

John: Have

Marjorie: Have a

John: A very

Marjorie: Very

John: Wide

Marjorie: Wide

John: Bore

Marjorie: For

John: Capillary,

Marjorie: Capital area,

John: Then

Marjorie: Then

John: You're

Marjorie: You're

John: Talking

Marjorie: Talking

John: About

Marjorie: About

John: Trying

Marjorie: Trying

John: To

Marjorie: To

John: Elevate

Marjorie: Elevate too

John: Too much

Marjorie: Much

John: Water

Marjorie: Here. That's

John: In

Marjorie: Right.

John: The gravity.

Marjorie: Gravity. It

John: It

Marjorie: Would

John: Would

Marjorie: Have

John: Not

Marjorie: Not

John: Enough

Marjorie: Enough

John: Glass

Marjorie: Glassy

John: Surface

Marjorie: Surface

John: Around

Marjorie: Around

John: It.

Marjorie: It. That's true.

John: It's so

Marjorie: So the

John: Low gravity

Marjorie: Gravity

John: Will

Marjorie: Will

John: Win

Marjorie: Win

John: Over

Marjorie: Over.

John: In,

Marjorie: Yeah.

John: So it's

Marjorie: It's

John: Not

Marjorie: Not

John: Going

Marjorie: Going

John: To

Marjorie: To

John: Rise.

Marjorie: Run. It makes sense to me.

John: So

Marjorie: So

John: Capillary

Marjorie: Capillary

John: Action

Marjorie: Action is

John: Is this

Marjorie: This

John: Interplay

Marjorie: Interplay

John: Between

Marjorie: Between

John: Adhesive

Marjorie: Adhesive

John: Cohesive

Marjorie: Cohesive forces,

John: Forces, which

Marjorie: Which

John: Can

Marjorie: Can

John: Be

Marjorie: Be

John: Counteracted

Marjorie: Counteracted

John: By

Marjorie: By

John: Gravity.

Marjorie: Gravity. I want you to say one more time. Let a

John: Cohesive,

Marjorie: Cohesive forces

John: Cohesive

Marjorie: Use of.

John: Forces are the interactions within the same substance. So you have a water molecule and you have a water molecule. How would we categorize that interaction between those two water molecules?

Marjorie: Cohesive,

John: We

Marjorie: We

John: Would

Marjorie: Would say

John: Say

Marjorie: They

John: They are

Marjorie: Are.

John: Cohesive

Marjorie: Who you see

John: Forces.

Marjorie: So closely work gray.

John: It's

Marjorie: It's

John: Still

Marjorie: Still

John: Dipole,

Marjorie: Dipole.

John: Dipole,

Marjorie: Dipole. Okay.

John: Whether

Marjorie: Wethers.

John: It's between the water and the water or the water in the glass. It's all dipole, dipole. But we categorized when it's two different materials that as adhesive, when it's one type of material

Marjorie: It's cohesive

John: We call

Marjorie: How

John: That

Marjorie: That.

John: Cohesive

Marjorie: In

John: In the

Marjorie: The

John: Interplay

Marjorie: Interplay

John: Between

Marjorie: Between

John: The

Marjorie: The

John: Adhesive

Marjorie: Adhesive

John: And

Marjorie: And

John: Cohesive

Marjorie: Cohesive

John: Forces

Marjorie: Forces

John: Can

Marjorie: Can

John: Cause

Marjorie: Cause

John: The

Marjorie: The

John: Water

Marjorie: Water

John: To

Marjorie: To

John: Move

Marjorie: Move

John: Through

Marjorie: Through tiny

John: Tiny capillaries.

Marjorie: Capillary, yeah.

John: They

Marjorie: They

John: Have

Marjorie: Have

John: To

Marjorie: To

John: Be

Marjorie: Be

John: Tiny

Marjorie: Tiny

John: Because

Marjorie: Because

John: If

Marjorie: If

John: They're

Marjorie: They're

John: Any

Marjorie: Any

John: Larger,

Marjorie: Larger

John: Gravity takes

Marjorie: Takes.

John: Over.

Marjorie: That's right. It would be overwhelming.

John: And this

Marjorie: This.

John: Explains how water can rise from the water table underground to the roots of a tree. That's actually capillary action that

Marjorie: It

John: Allows

Marjorie: Allowed you

John: The water

Marjorie: To

John: To creep

Marjorie: Creep

John: Upward

Marjorie: Upward

John: To

Marjorie: To

John: The

Marjorie: The

John: Roots.

Marjorie: Roots and

John: The

Marjorie: Tree

John: Tree is

Marjorie: Is

John: An

Marjorie: An

John: Actively

Marjorie: Actively

John: Sucking

Marjorie: Sucking

John: Up

Marjorie: Up

John: The

Marjorie: The

John: Water

Marjorie: Water

John: From

Marjorie: From

John: Underground.

Marjorie: Underground.

John: Well, it's

Marjorie: It's

John: Just

Marjorie: Just a

John: A natural

Marjorie: Natural

John: Capillary

Marjorie: Capillary

John: Action

Marjorie: Action

John: That

Marjorie: That really

John: Brings

Marjorie: Needs

John: The

Marjorie: The

John: Water

Marjorie: Water

John: Upward.

Marjorie: Upward.

John: It draws the water

Marjorie: Because

John: Upward

Marjorie: Because

John: Because

Marjorie: There

John: There

Marjorie: Are

John: Are little

Marjorie: Little

John: Teeny

Marjorie: Teeny

John: Tiny

Marjorie: Tiny

John: Little

Marjorie: Little

John: Capillaries

Marjorie: Capillaries

John: Pathways

Marjorie: Pathways

John: Through

Marjorie: Through

John: The

Marjorie: The

John: Soil,

Marjorie: Soil,

John: Which

Marjorie: Which

John: Is

Marjorie: Is

John: Why

Marjorie: Why

John: A really

Marjorie: Really

John: Compact

Marjorie: Compact soil.

John: Soil, it's not going to happen. So

Marjorie: So

John: The quality of the

Marjorie: The soil

John: Soil is

Marjorie: Is

John: Important.

Marjorie: Important.

John: Good

Marjorie: Good

John: Quality

Marjorie: Soil

John: Soil is

Marjorie: Is

John: The

Marjorie: A

John: Soil

Marjorie: Soil

John: That

Marjorie: That

John: Has

Marjorie: Has

John: Those

Marjorie: Those

John: Little

Marjorie: Little

John: Capillaries

Marjorie: Capillaries

John: Through it that

Marjorie: That

John: Allows

Marjorie: Allows

John: Water

Marjorie: Water

John: To

Marjorie: To

John: Permeate

Marjorie: Permeate

John: Throughout so

Marjorie: So

John: That

Marjorie: That

John: It

Marjorie: It

John: Can

Marjorie: Can

John: Get

Marjorie: Get

John: To

Marjorie: To

John: The

Marjorie: The

John: Roots.

Marjorie: Roots.

John: Right.

Marjorie: Right.

John: All

Marjorie: All

John: Right.

Marjorie: Right.

John: Ready

Marjorie: Ready

John: For

Marjorie: For

John: The

Marjorie: The

John: Next

Marjorie: Next

John: Section.

Marjorie: Section. I know, but

John: I'm

Marjorie: I'm

John: Just

Marjorie: Just

John: Seeing

Marjorie: Seeing

John: Why

Marjorie: Why

John: It's

Marjorie: It's

John: So

Marjorie: So

John: Hard

Marjorie: Hard

John: To

Marjorie: To

John: Plant

Marjorie: Plan

John: Things

Marjorie: Things

John: In

Marjorie: In

John: The

Marjorie: The

John: Middle

Marjorie: Middle

John: Of

Marjorie: Of clay,

John: Clay, which

Marjorie: Which

John: Is

Marjorie: Is what

John: Intact.

Marjorie: You do in Texas.

John: All

Marjorie: All

John: Right.

Marjorie: Right. Go on.

John: Well, actually, I'm thinking we're at a good stopping point. We've made it through the first half. This chapter on the remarkable properties of water. Mom, you're an awesome co-host. Might you be willing and able to stick around for the second half?

Marjorie: I think this wonderful.

John: Awesome. All right. We're gonna do this. Appreciate it. Hey, listeners. Thanks for tuning in. In the next episode, we'll be exploring how water transforms into the gaseous phase as well as how water behaves very much like a heat sponge, which has all sorts of environmental implications that we'll talk about. So till next time, good chemistry to you.

Marjorie: Let's

John: Let's

Marjorie: Go

John: Go

Marjorie: Make

John: Make

Marjorie: A cup of tea.

John: Our theme music by Zack Jefferey Musical Flourishes by George frideric Handel selections from his Water Music Suite in F Major. Our thanks to Marjorie Hewitt to Hockey Emeritus Professor and Dean of the Claremont School of Theology. Production assistants from Greg Simmons. And C Pro Music for show notes and more. Please visit conceptualscience.com. A note of appreciation to all instructors using conceptual academy. Thank you for your support and to the hardworking student. Our thanks to you as well for your learning efforts, which we see as the path to making this world a better place. There's a bigger picture that's good chemistry, good chemistry to you.