

The following content is provided under a Creative Commons license. Your support will help MIT OpenCourseWare continue to offer high-quality educational resources for free. To make a donation or to view additional materials from hundreds of MIT courses, visit MIT OpenCourseWare at ocw.mit.edu.

PROFESSOR: So today, what we're going to be doing is-- last week, you gave us some feedback what you wanted to do in the class. We're going to go through that and talk about the readings. I'm going to do a little calling on you and helping you take the class through the readings.

And then the six or seven things I'm going to do-- history of money; ledgers; fiat currency, central banks, and credit cards; the role of money; some early digital money. You had the Clark reading as to a bunch of failed attempts. All the way through a little bit of mobile money, all the way up to Starbucks and Alipay. And yet, the riddle remains. We're going to get really deep into Bitcoin in the next three classes. But this is to give some foundational bits of money and ledgers and central banking and technology.

And then, of course, I always like to finish the class talking a little bit about why we're doing what we're doing between now and then. Even though the readings are required, I know you're all busy. I know that you've all got a bunch of classes. And like good business students and business people, you optimize. So I'm trying to give you a sense of why you might read it, rather than it's required, at the end of each class and how it fits into the course narrative. And then we'll do a little bit of conclusions.

So the survey results. What did you want to learn? This is really your class, and I'm going to learn as much from you. But hopefully, we're going to cover what you want. So here's a list of those things that were at least written by two of you. First was technical things. 18 of you said understanding blockchain technology. Hopefully, we get to that, but you might find that you'll want to do more after this class.

The ecosystem and being able to have an educated discussion, sort of the dinner party conversation around blockchain. I think we'll be successful. But at the end of the semester, we're going to pull these slides up again, and we'll see how we did as a group. You all talked a lot about applications. How can you actually apply it, learning in the venture space and thinking about where it really works in the world.

And I think we're going to spend a lot of time on that in the second half. But all throughout, we're going to be talking about the economics and what's the reality versus the hype. You also wanted to understand its impact on people's lives, the regulation. About six of you said something about regulation. I'm glad, because we're only doing one lecture on that. But we're going to spread it out, because as we talked about in our first class-- and I'm honored Larry's here again-- but we're going to always be thinking about Larry's four ways.

And I see-- is it Jihei? What are Larry Lessig's-- you shook your head yes.

AUDIENCE: I know-- let's see. It is code and architecture, market, law, and norms.

PROFESSOR: You got it. Does anybody want to say how that relates to blockchain, why we're chatting about that? Oh, my god, I'm going to have to cold call fast, right? You're from R3. Joe?

AUDIENCE: No, I remember we saw it last class, but I can't relate it now to blockchain.

PROFESSOR: Can you relate it to anything in life? Maybe not. Alan, help your tablemate out.

AUDIENCE: I'm waiting for my moment to shine.

PROFESSOR: This isn't it.

AUDIENCE: This isn't it.

PROFESSOR: I'm having fun. This is what I'm going to do. I'm just going to have-- don't worry about it. So why do markets, code, law-- I can't see your name, but is it [INAUDIBLE]? Yeah, why? Why does that relate to all this?

AUDIENCE: Can you repeat the question?

PROFESSOR: Jihei, you're going to repeat the question, because you went through it.

AUDIENCE: So how does Larry's four forces relate to our topic of blockchain.

PROFESSOR: And the four forces, again, are market, so business; law; code or architecture, call it technology; and social norms.

AUDIENCE: So I think it's because it brings a new way of doing those things, like a new tool in order to-- so what I got from the reading is these ledgers already existed, but given that now we have big data, for example, then more things going on helps our society roll it out better.

PROFESSOR:

Good way to say it. Look, it's unfair of me. It wasn't one of the readings. I'm just saying, in everything in life, I find these things grind up against each other. I spent a lot of time in Washington in politics, but the markets and how the commercial enterprise and the economy grinds up against technology and sort of grinds up against the law-- and then, of course, just social normative behavior. These four forces, in almost everything one does in life, you will find.

And so I just ask you to always, whether it's one reading or another reading, bring that into your thought process of this class. I'm not going to assign Larry's assignment. I didn't know he was even going to be here. But I've always thought it's a good discipline to think, OK, what are the commercial realities, the markets?

What's the technology, even if it's in an earlier day and it's the technology of the car replacing the horse and carriage? How does government or the official sector put it into a set of standards that are required? And then how do we, as a society, even if it's not required, just have our behaviors? Those are the four forces. So that's why. I probably just failed Larry's class, but that's how I've thought about it. I did, probably, right? No, he's shaking his head.

But regulation is just one of those four forces. And that's why I pause there. And so we'll have it in every class, but only one lecture.

Money and markets, that's one of the other forces. Five of you said you want to make money, and I applaud those who said that, because own it. You're in a business school. Why not? But investing and trends. Now, there was a bunch of other miscellaneous topics. I'm not going to go through them. I kind of thought the last two were interesting-- anecdotes from my past. I'm not sure who said that. I'm not sure what you want to know about-- my three daughters, my running, or this Wall Street stuff and finance.

And I'd like to understand hyperbitcoinization, as well, but I don't know who asked that question. I don't know what it is, so I'll try to figure out what hyper-- does anyone want to own up to that question? They were anonymous. All right. All right.

So today's study questions. What's the role of money historically and in today's digital economy? And this is when I'm going to look for discussion. So does anybody want to tell me what the role of money-- what would be your answer to this? Anton?

AUDIENCE: The medium of the transaction, and the unit of-- like a counting unit. And also, the state of the value.

PROFESSOR: So the three classic rolls of money that people talk about. Kelly, you want to repeat what he just said?

AUDIENCE: [INAUDIBLE] the question, but I think historically, it was pay off debts, starting and conquering various lands and wards, and then also funding trade wars, cutting taxes. So a lot of societal things that drove civilization forward.

PROFESSOR: And what we'll discuss today and what it is, is that money is a social construct. It's something that societies came together-- it's hard to tell whether it was 5,000 years ago or 8,000 or 10,000 years ago. Really, it's a social consensus mechanism. But we're going to chat about the readings in a minute and come back to that question. What is fiat currency? Does anybody want to-- Tom, you want to tell us what fiat currency is? It's a shame, Tom. See, I recognize you.

AUDIENCE: [INAUDIBLE]. This is like a established currency by a central government, by a government that proposed a market or [INAUDIBLE].

PROFESSOR: Right. So you said it's a central currency, and it's by government. Anybody else want to add some things? Is it Kyle?

AUDIENCE: I would just add that it's not backed by any physical commodity.

PROFESSOR: So it's not backed by any physical commodity.

AUDIENCE: Yeah. Really just the good faith and credit of the nation that issues it.

PROFESSOR: Daniel, did you want to add anything?

AUDIENCE: I was just going to say somewhere that it's not gold backed or anything like that.

PROFESSOR: But was it always that way?

AUDIENCE: It wasn't originally that way.

PROFESSOR: Right. A fiat currency might be backed by something physical. Was there other-- remind me your name. I'm sorry.

AUDIENCE: Josh.

PROFESSOR: Josh.

AUDIENCE: Specifically used to settle debts, specifically those to the government, so taxes.

PROFESSOR: All right, so it can be used for taxes. And remind me of your name, because I can't see a card. What?

AUDIENCE: Sean.

PROFESSOR: Sean.

AUDIENCE: So, basically, there's no inherent value in fiat currency. So basically, there's no one recognize that specific currency itself. There's no government.

PROFESSOR: So here's a question for the class. Is there inherent value to non-fiat currencies? Because Sean's saying that maybe a distinguishing characteristic of fiat is it has no inherent value.

AUDIENCE: Terry.

PROFESSOR: Terry.

AUDIENCE: Well, actually, the same applies to any commodity that's used to-- currency in general. Because it's just the scarcity of some specific resource and social common agreement that that's going to be the parameter.

PROFESSOR: So how many people are more in line with Eric or-- there's not one right answer to this. This is a question that's been debated for decades or centuries. How many are more in Sean's camp?

AUDIENCE: I think it depends. For example, gold is definitely a social construct. We decide that, as a human society, that gold is going to be something valuable. But if it's, like, grains that humans can [INAUDIBLE] and that, I think, has an inherent value. So I think there are non-fiat currencies that does have inherent values and that does not have inherent values.

PROFESSOR: All right, anybody-- what's your-- Jihi, yeah. Tom? Tomas?

AUDIENCE: Tomas. I just want to say that the [INAUDIBLE] is another component which the fact that it is a legal tender. So the government and some [INAUDIBLE] forced the society to use the

currency, which makes more comfortable for people to use.

PROFESSOR: So Tomas is saying that fiat currency is legal tender. So first, we have to discuss, what is legal tender? Does anybody want to knock that one out of the ballpark who hasn't raised their hand yet? No? All right.

AUDIENCE: I think that's maybe my earlier comment. It can be used to settle debts, and specifically those to the government. So you can use gold as a money. It can be a stored value. It can be a means of exchange. But you can't pay your taxes in gold, right? You have to--

PROFESSOR: Is that correct? So 19th century, could you pay your taxes in gold in the US and in Britain and other countries that had gold currency? This is just a yes or no, but James?

AUDIENCE: It's yes, but after 1970s, the paper currency is attached to the gold standard. So inherently, there is an exchange of value that is picked by the government or the central bank. So it's almost one of the same thing at that time, until more recent years.

PROFESSOR: James is saying you could use gold as legal tender. Legal tender, again, is something that a society comes together and creates a law-- back to the Lessig four. Society together says-- it's not just a social normative behavior. It's a law. One must accept this. And the US and the UK and many countries it says for all debts, public and private. So a debt to the government or a debt in a store.

We're going to get to, later, as to when is it true that somebody has to take your cash. But I'm going to hold off on that in a minute and talk about it. But I think, also, Jihei said-- it was somewhere between Sean and Eric, both physically in the class and in terms of her articulation-- that fiat currency might not have anything inherently behind it. But gold mostly doesn't have anything inherently behind it. And then some forms of currency, like grain, had more.

So maybe it's a continuum. Maybe it's not black and white, 100% or 0%. And then we're going to talk a little bit about how Bitcoin fits into it. And our next three classes are going to be really into the technology of Bitcoin, but just a little bit of teasing out before I go through some lecture slides. Who wants to talk about how Bitcoin might fit into this history of money? And then I'm going to return to that question in about 45 minutes and ask you again. Does anybody want to say from the readings? And you remind me your name?

AUDIENCE: Isabel.

PROFESSOR: Isabel.

AUDIENCE: So with Bitcoin, it's kind of the same, where the value is given by society, except with Bitcoin, it's not backed by a central bank. So people don't think that there is an inherent value. But the readings pointed out that there's sort of that same history, except it doesn't have [INAUDIBLE].

PROFESSOR: So Isabel is saying that Bitcoin fits into the history of money because, like fiat currencies and like Jihei said about gold, it doesn't necessarily have any inherent monetary value, but it's a societal set of norms that people are accepting it as having value. But the key distinction that Isabel said was that it's no central.

AUDIENCE: It's not backed by any kind of central bank.

PROFESSOR: It's not backed by a central bank or a central authority. Alan?

AUDIENCE: Yes. So Bitcoin, in my opinion, is unique, because I think the value of Bitcoin changes over time, not the fluctuation that we see like \$6,000 or \$90,000, but in terms of the utility of the coin itself. So today, for example, we might be able to buy pizza or coffee or whatever with Bitcoin, so there is an inherent value in terms of medium of exchange. And it will change as society adopts it more and more. So I think it's hard to define if there is inherent value or not.

PROFESSOR: So Alan is raising that Bitcoin-- if I can put some words in your mouth, and tell me if I'm correct, that Bitcoin might have some distinguishing features from even fiat currency, that its value is shifting over time with adoption. Is that-- I mean, you didn't use that word. Please let me know your name again.

AUDIENCE: Brotish.

PROFESSOR: Right. Like British, but with an O, you told me earlier-- Brotish.

AUDIENCE: Another way I was thinking of [INAUDIBLE] the evolution of the later technology like accounting and the evolution of money, along with-- so initially, we saw in the reading how it happened in the prehistoric age and then the advent of the [INAUDIBLE] and then [INAUDIBLE] later, which is kind of one of the fundamental blocks of Bitcoin.

PROFESSOR: Right.

AUDIENCE: So that is another way kind of natural progression of how money [INAUDIBLE].

PROFESSOR: Brotish?

AUDIENCE: Yeah.

PROFESSOR: So what Brotish has raised is also Bitcoin fits into the history of ledgers, whether it's double entry ledgers as recognized through T accounts or other forms of ledgers, that it adds to this whole long history of ledgers. I agree with that. And it's a new form of keeping ledgers. Alan?

AUDIENCE: So Bitcoin is also similar to gold. There is an element of scarcity.

PROFESSOR: Of scarcity.

AUDIENCE: Yeah. So you cannot generate that many Bitcoin.

PROFESSOR: Correct.

AUDIENCE: You can only generate 50 bitcoins every 10 minutes, and it keeps happening every four years.

PROFESSOR: So it seems like scarcity and ledgers are important components. Aviva?

AUDIENCE: Yes. So it does have a fixed demand-- sorry, a fixed supply, like you said, in terms of scarcity. But the more we adopt it, the more it becomes divisible in terms of units. And so we can increase its use, because now you can divide them up to [INAUDIBLE].

PROFESSOR: This is good. So divisibility is another characteristic of money, scarcity, adoption as Alan said, ledgers. Sorry, Tomas?

AUDIENCE: We mention decentralization, because this implementation make feasible the Bitcoin and makes feasible to implement this kind of thing in the decentralized environment. So without any central authority to design or dictate the supply and all the aspects of the concepts.

PROFESSOR: We'll take one more, and then I'll start to talk about the history. Why don't we go here? And remind me your name.

AUDIENCE: Alexis.

PROFESSOR: Alexis.

AUDIENCE: [INAUDIBLE] of like money and other forms of currency, even if it's controlled by central government or central bank, there's no fixed exchange rate. It trades extremely quickly with

other types of currency, so I mean, it's still very different.

PROFESSOR: So, Alexis, if I understand Alexis' point, it's that there's no fixed exchange rate about Bitcoin we're talking about. But couldn't we really broaden that to all forms of currency? I mean, what really is the exchange rate between an ounce of gold and a bushel of corn?

AUDIENCE: Yes and no. I mean, yes, that, for example, some states do control exchange rates with other countries.

PROFESSOR: All right, good point. So Alexis is saying yes and no, because some governments try to fix. Now back to markets. How well does that work when governments try to fix an exchange rate? I mean, just as a sense of the class, does that work well? So it sort of might work well in temporal, short periods. Works less well for decades on end. I'll take one more, and then I'm just-- I want to go through a couple--

AUDIENCE: Just one comment. That way you can teach hours of work. That's how economies define it previously, right? But I just want to ask, what is a ledger?

PROFESSOR: What is a ledger? Very good question. I'm going to be chatting about that in a minute. But does anybody want to hit that? I'm sorry. No, over here.

AUDIENCE: I was going to say, it's just a numerical record of everything recorded, in a fashion.
[INAUDIBLE].

PROFESSOR: A numerical record. I think that's a good thing. A ledger is basically a way to record economic activity or social relationships or financial relationships. I would say it's both a way to record economic activity, and it's a system of recording financial relationships. And while I didn't assign these readings, some very good academic research suggests that the first methods of writing and symbols of writing had to do with numbers and had to do with ledgers, rather than words and communication.

Because it's so fundamental to society to record various economic transactions or to record the financial relationships amongst and between members of a community, whether it was a small village or when society burst out of villages thousands of years ago. Does that help? We'll be back to it. And better that you ask that here than in your accounting fundamentals class. I don't know.

So the readings-- we've sort of talked about the readings. How many of you actually watched

the little three-minute video? What'd you think? I mean, just as a-- I'm sorry, here. We haven't chatted yet.

AUDIENCE: I think the broad-based message was that any currency, or anything, for that matter, has value equivalent to what the society assigns it with. Because the video basically just showed a guy who created his own currency and was just selling it to the public. And his whole claim was that it is real if you believe it is real.

PROFESSOR: So it was just a nice little ditty, in a way. Matthew, I'm sorry?

AUDIENCE: I would have given him \$1 for it.

PROFESSOR: You would have given him \$1? Great.

AUDIENCE: Seeing how much the pizzas went for.

AUDIENCE: Who knows?

PROFESSOR: Would anybody else have given him \$1 for it? No? Oh, you would have?

AUDIENCE: Actually, I'm working with local currencies. And it's kind of the same, but you can use them just locally. I mean, it keeps the money inside the community that decides to use that way of transactions.

PROFESSOR: We're going to refer back to each of these readings as we go through the next 45 minutes. Yeah?

AUDIENCE: I was wondering if he was actually breaking the law by launching his own competing currency to the US dollar? Is that a legitimate-- obviously, it didn't compete with the US dollar, but--

PROFESSOR: You raise a very good question. I'm not aware of any statute, federal or state, that says there's an absolute monopoly on forms of currency as there is in other things, like you know that slot in the door that's called the-- where you can put a letter through the door or a mailbox? There's actually a law that says that the US Postal Service has a monopoly, and that's why UPS is not allowed to put their boxes or anything in there. There's a government fiat monopoly.

But you raise a very good question. What we've found in the last 10 years with Bitcoin, with really oversimplifying, is that it is legal to create your own form of money, as Bitcoin is possibly

this money. But you have to comply with all the other laws. And all those other laws that we'll talk about in other lectures, in essence, fall into buckets of guarding against illicit activity, so the Bank Secrecy Act and all the laws related to anti-money laundering and terrorism finance and so forth.

One still has to pay your taxes if you're gaining or losing on this investment. The Federal Reserve and other authorities around the globe still want to insure for financial stability. The fellow on the streets of-- I don't remember what city. New York? Selling his dollars, when Matthew bought it for \$1 and I think over here-- Brianna?

AUDIENCE: [INAUDIBLE]

PROFESSOR: What's that?

AUDIENCE: My name?

PROFESSOR: Yes.

AUDIENCE: [INAUDIBLE]

PROFESSOR: Bought it. The society's still going to be stable. It's going to be all right. But if millions of people were buying it, then people might worry. And then there's the third big bucket that we look at is investor and consumer protection. But I think it's allowed. So we'll refer to these, Joaquin, and then I'm going to go on.

AUDIENCE: Can you legally pay, for example, salaries in bitcoin in the US?

PROFESSOR: Yes. And why is it that you can legally pay for wages in bitcoin in the US? I know it's outside of the readings, but why do you think it is allowed in this society? Is it Kyle?

AUDIENCE: Wouldn't those compensation forms be allowed under any contract?

PROFESSOR: Most things-- you could pay somebody in these placards. I doubt, really, that you're going to value them much. But you could pay somebody in this. You could pay somebody in gold, euros, bitcoin. And there are firms that are paying-- usually, they're developing blockchain applications. And interestingly, they have to compute the value of the wages to do withholding taxes, because the US government will not accept taxes in bitcoin.

So they figure out the fair market value-- and there are companies in the US that pay people in

bitcoin who are doing development work around blockchain applications. But the taxes need to be computed and analyzed and then paid in US dollars. There was a legislative initiative in Arizona earlier this year where a state legislature wanted to have Arizona be the first state in the land to accept bitcoin for taxes. But it failed in committee. It didn't even get a full vote of-- I can't remember if it was the Arizona Senate or the Arizona House of Delegates.

So just a little walk through the history. I was going to do a little history of money and have some fun. So in Ethiopia, people put together salt bars. This is not that long ago. Salt, as Jihei said earlier, is really valuable in society, and they standardize the shape and size. And so here's salt bars. We're going to get to, a little bit later, all the characteristics of money. But what else do you think a salt bar in Ethiopia, as opposed to maybe some other country-- what did it have, as well, as to why people might use that?

AUDIENCE: Oil.

PROFESSOR: What's that?

AUDIENCE: Crude oil.

PROFESSOR: Crude oil. All right, I hadn't thought of that. I'm going to keep thinking about that. It's not a common characteristic of money. But why salt bars? What else might it have in Ethiopia?

AUDIENCE: Are you going to say that you can use salt to preserve food?

PROFESSOR: Well, you can preserve food, but because it was mined, there was some scarcity, as well. And a lot of currencies, a lot of moneys over time, have that fundamental issue. Cowrie shells from West Africa. Does anyone know the history of when cowrie shells got really debased and stopped being used, from the readings? I can't remember if that was in the readings or not.

They got debased when Europeans started to realize that they were accepted as a value. And it's a very sad and terrible history, too, because it's related to the whole slave trade. But that the Europeans could figure out that societies accepted this as something of value, but they also debased that currency and they debased the land and captured people as slaves. It was quite a collection of not particularly good things going on.

Tally sticks in England. Does anybody, from the readings-- because there was a little bit of the debate in the first reading about the history of money-- want to chat? And I'll pull up the Rai stones from Yap. How this fits into that first reading and the debate between did money come

from a history of barter, or did money come from a history of ledgers and credit, which is kind of a setup of that first reading? Any thoughts? Which ones of these four bits of money, early money, are more about maybe barter?

AUDIENCE: There are two theories, right? Debt, which corresponds to this one. This was a way to measure debt.

PROFESSOR: Which one?

AUDIENCE: The sticks.

PROFESSOR: The sticks. The tally sticks, yes, correct. Which is the second one on here that has to do with debts, actually, and credits?

AUDIENCE: The stones.

PROFESSOR: The stone, the Rai stones. So it's remarkable. The Rai stones were so heavy that on this island of Yap, they couldn't possibly lug it around and use it in a traditional medium of exchange. But it was viewed as, well, I have 1/6 of this Rai stone. You have 1/16. And then if I make an exchange, we'd remember.

And the society was small enough to keep a form of ledgers, even to the extent that when a Rai stone was lost in a river, they said, you know, the river Rai stone, we each have this piece. So on the island of Yap, I can assure you, these stones could not be used for anything else. Does anyone know, because it was outside the readings, what made these stones so scarce? So Rai stones were quarried on an island about 200 kilometers away from Yap, so were they exceedingly hard to get, like gold, like mining of gold. What else is mined these days that might be a money?

AUDIENCE: Lithium.

PROFESSOR: What's that? Can I hear everybody?

AUDIENCE: I'm saying lithium.

PROFESSOR: What's that?

AUDIENCE: For batteries. For batteries. It's going to be very difficult in the future for electric batteries and whatnot.

PROFESSOR: But what's mined right now that's at the center of this class?

AUDIENCE: Bitcoin.

PROFESSOR: Bitcoin, right? The Yap stone was, in essence, quarried a couple kilometers away. And what debased that currency was when sailors from England came. There's a specific sailor-- I think his name was O'Keefe-- in the late 19th century, and he realized that these stones were valuable. And he went to the other island, and he started quarrying and came back and forth. And within a few years, the whole economic system collapsed.

We moved to metal money. At first, it wasn't really stamped. It was just heavy. It was hard to quarry. Bronze in Rome. There was some China and Sweden. These were starting to be stamped by the official sector. And then we had minted money starting somewhere around 2,500 years ago. And there's debates as to whether it started in Greece or in China. But where an official emblem was placed upon a scarce resource that was used.

Paper money came along, in a sense, for what reason? Why did society first tip in to paper money?

AUDIENCE: Because there's not enough gold to back it up. I mean, like because there's--

PROFESSOR: All right. One reason is not enough gold. I'm sorry, I haven't--

AUDIENCE: I think it's just easy to--

PROFESSOR: Ease of use. It's kind of heavy, especially if there wasn't gold and if it was copper or bronze. It was just heavy. Or if it was wheat, you'd have to put it in a storage unit. So the first paper monies from China were basically warehouse receipts. And I spent five years running something called a Commodity Futures Trading Commission, and so I guess I learned a lot about warehouse receipts, commodity receipts, where you put a commodity in a warehouse. And then you got a piece of paper that said, yes, you have that commodity there.

So the first paper monies were basically warehouse receipts in China. Because whatever it was-- grain or gold. And then you had a piece of paper backing it. These are five pound notes from England and the continental notes of the US. But that note in China is about 700 years old. But between that first paper money and the 18th century, who do you think we're kind of the first bankers in the late 17th century, early 18th century? What craft had they been in before they were in banking?

AUDIENCE: Trading.

AUDIENCE: Trading.

AUDIENCE: Trading.

PROFESSOR: Alpha?

AUDIENCE: International trading.

PROFESSOR: International trade. They actually did something more local.

AUDIENCE: I just talked about this. The ones that have lands and all the-- the ones that have lands and all the [INAUDIBLE].

PROFESSOR: Lanes?

AUDIENCE: Lands.

AUDIENCE: Land.

PROFESSOR: Land. Land. No, they had something else that they were doing. Tom?

AUDIENCE: Printmakers.

PROFESSOR: They were printmakers. I like that. We're not there yet.

AUDIENCE: Money lenders?

PROFESSOR: What's that?

AUDIENCE: They're underwriting insurance.

PROFESSOR: A little bit later.

AUDIENCE: They were doing agriculture?

PROFESSOR: It's definitely outside of the reading. They were goldsmiths. Some of the first dominant bankers in London, they were small goldsmiths. And they took the gold, they gave you a piece of paper, and then they went from there. And then, all of a sudden, they figured out how to do credit.

Later in the semester, we're going to talk about Bitcoin credit. It's not there yet, by the way. I think in the next 18 to 36 months, we're going to start seeing cryptolending and cryptofinance in the form similar to what the goldsmiths were doing in the early 1700s in England. Alan?

AUDIENCE: Is that scalable with a finite number of bitcoins, in your opinion?

PROFESSOR: It's a very good question. Is it scalable to lend against a finite currency? I think so, but it's not done yet, right?

AUDIENCE: Yeah, because when you lend money to someone, I guess it could be in the form of bitcoin. But you lend someone dollars, they could redeem in bitcoin. You'd be increasing kind of the money supply. So you don't need-- you're not moving money around. You're actually [INAUDIBLE].

PROFESSOR: So this is exactly the central of commercial banking today. It's called fractional banking. We'll be talking about that in a bit. But yes, you could lend and then have a multiplier effect. You also had, then, banks come up and started to issue private bank notes. Private bank notes effectively a liability of that bank and saying it would trade. And the history of private bank notes is usually what? Good until it's really bad.

And the history of money, a lot of private banks went bust in this country around the revolutionary period, again around the Civil War. And in essence, that's what we have now with 1,600 different cryptocurrencies. We have sort of a new period of a little bit of private currencies. And I only ask you to remember that as we start to look at ICOs, Initial Coin Offerings, and so forth.

So ledgers-- the earlier question is, what was a ledger? You asked it. Can you remember, what's a ledger?

AUDIENCE: It's a way to record economic transaction.

PROFESSOR: There you go. Principal recordings of accounts. And 5,000 years ago-- you had a little reading on this, just a medium post. It wasn't meant to be a deep economic, academic paper. But it was to try to get the class thinking about ledgers. This is the personal ledger of George Washington, our first president. He was 15 years old when he kept this ledger. And he apparently kept ledgers until his death in-- let's see. 52 years later.

So ledgers could be kept just to record the transactions of the day. He's got one up there--

Mary Washington. It must have been a cousin, or I can't remember if it was his mother. So if they're the principal recordings of accounts-- and I've already sort of said this-- they record economic activity and financial relationships. Economic activity in a sense of transactions. Financial relationships-- what's a key financial relationship a ledger might record? I'm sorry?

AUDIENCE: Debt.

PROFESSOR: Kelly said it-- debt. And it goes back to the debate you had in the reading. Is money a history of barter-- did it come out of barter? Did it come out of a sense of debts and credit and store of value? For this purpose today, it doesn't really matter. It may have come from both. But know that it has both sides. And ledgers have both sides, too.

And when we're talking about Bitcoin, Bitcoin, you will see, is a mechanism to store transactions. Some other blockchains, like Ethereum, stores balances. So even in the blockchain world, you will see some that are balance ledgers and some which are transaction ledgers, not to lose you and confuse you. It's an important part of what is blockchain.

Some types of ledgers. I just mentioned one-- transactions versus balance. George Washington's ledger, by the way, I think was a transaction ledger. He was just keeping a list of sales and movements. But I haven't studied President George Washington's ledger close enough.

Does anybody know enough accounting to tell me the difference between a general ledger and a subledger or a general ledger and a supporting ledger? I mean, I don't want to do the whole lecture myself. How many of you have taken accounting? Uh-huh. I taught undergraduate accounting once. Sorry. So those of you who just put up your hand who took accounting-- did I see, in the back of the room, did you take accounting? And that's Aviva.

AUDIENCE: I'm an accountant, actually.

PROFESSOR: You're an accountant? All right, all right. Did you pass the CPA? Oh, we have a Certified Public Accountant who's going to tell us the difference between a general ledger and a subledger.

AUDIENCE: So a general ledger is one that records all kinds of transactions. Any kind of activity that takes place, you record in the general ledger. And subledgers, you can call them as like a specialization. So let's say if there's a salary to be paid, you have your salary subledger. But it'll also go in the general ledger, and the other part of the transaction's in the salary ledger.

Or if there's capital or if there's new stuff that you buy, so all of that goes specifically in the general ledger. And each of them have their own specific ledgers. If you want to say how much you spent on Saturdays for the month, then you go to your Saturday ledger and see. But if you want to see, overall, how much money you've spend and how much has moved around, then you look at your general ledger.

PROFESSOR: Aviva clearly said it better than I could have. Thank you. Now we know we have one CPA in the class. But the importance-- it's not just a passing note. The importance of a general ledger and subledgers is there is a hierarchy, as well. Subledgers have more detail, and maybe the net number is kept in the general ledger.

That is at the heart of our system of banking and is at the heart of our system of financial markets, where the central bank is like a general ledger for money, and every commercial bank, all 9,000 of them or so in the US, in essence keep a subledger for money. But they do not have control of what I will call the master ledger or general ledger at the Federal Reserve.

Then, a third distinction about ledger is a single entry. A little, young, 15-year-old George Washington was keeping a single entry ledger-- just a list of things that was going on. And I didn't think I was going to bore the class with readings about double-entry bookkeeping, because you've taken accounting. But does anybody want to tell me, other than Aviva, what double-entry bookkeeping-- and she'll bail you out. [INAUDIBLE]?

AUDIENCE: Double-entry bookkeeping basically means any transaction has two places in the lender-- one on the credit side and one on the debt side. Because every transaction involves one person lending, whereas the other person is getting the thing.

PROFESSOR: It works for me. Anybody else want a different view?

AUDIENCE: In other words, [INAUDIBLE] asset and liability [INAUDIBLE] two sites and then [INAUDIBLE] to balance each other [INAUDIBLE].

PROFESSOR: So there's a balancing between assets and liabilities, and then the resulting bit of capitalism in it is if assets are more than liabilities, the rest is capital. So at the heart of capitalism, in a sense, is double-entry bookkeeping. And in fact, while it probably goes back a little over 1,000 years, when it was truly written up by the Italians in the 1300s, it started to help Europe come out of the Dark Ages.

I mean, the commercial Renaissance of the Middle Ages, some would say, was in part-- not entirely, but in part-- on the backs of double-entry bookkeeping. So ledgers matter is my point. They're not going to be the heart and soul of this class, but Bitcoin, which is a transaction ledger, Ethereum, which is a balance ledger, our financial system, which is all set up on ledgers is a relevant sort of subtext. You don't have to be afraid of it, just as you don't have to be afraid of hashing power that we'll be talking about on Thursday and cryptography.

You have to have some sort of basic sense of where does Bitcoin fit in, in terms of ledgers. I didn't feel this slide in. You'll find out it's blank. Does anybody want to tell me what are some characteristics of a good ledger? Because again, as you start to think about your blockchain projects later in the semester, it's like, what makes a good ledger? I don't have any answers here.

AUDIENCE: The bitcoin were immutable.

PROFESSOR: So you want it to be immutable, maybe. Thalita can you do me a favor and keep these? We'll put them on the slides. We'll keep the class's list, and we'll put them in the slides. Immutable, I like that. Anybody else want to grab something which is a good ledger?

AUDIENCE: Time stamped.

PROFESSOR: What's that? Time stamped, all right, so that you know when you made your entry. Kelly?

AUDIENCE: Ownership.

PROFESSOR: Ownership. What do you mean by ownership?

AUDIENCE: Essentially, the receiver and the person giving. So essentially, who's taking what and who's giving what.

PROFESSOR: So if there's a transaction, the two counterparties to the transaction, right? And if it's a balance, then who owns the balance? I was just adding a little bit. Let's see if we have a new name or face. Back here, on the back table. I haven't chatted with you yet.

AUDIENCE: Ross.

PROFESSOR: What is that?

AUDIENCE: Ross.

PROFESSOR: Ross. Thank you, Ross. Good to meet you.

AUDIENCE: Pleasure to meet you, as well. Accuracy.

PROFESSOR: Accuracy. So Ross says accuracy. And can we take one or two more, just to--

AUDIENCE: So a description of the transaction.

PROFESSOR: Andrew says a description of the transaction. And last, Mr. [INAUDIBLE]?

AUDIENCE: Comprehensive.

PROFESSOR: What's that?

AUDIENCE: Comprehensive.

PROFESSOR: Comprehensive. So all good attributes of a-- characteristics. Somebody's burning desire that we missed one or two? Jihei? All right.

AUDIENCE: I just was curious. Consistency, maybe? But I don't know if that's--

PROFESSOR: Consistency. Well, I think that's inside of immutability, that, in essence, that it's valid, that you can't change it. You can't counterfeit it and the like. And what you'll find is the characteristics of a good ledger is also, in some part, similar to the characteristics of good money. They're not identical, but they overlap a lot.

Payment systems-- I'm just going to say one line about it. It's a method, basically, to amend and record changes in a ledger for money. I know it's not what you usually think about a payment system. But if you go into Starbucks and buy a cup of coffee and use your cell phone, aren't you really just amending a set of ledgers? Starbucks' ledger goes up, and yup, your ledger goes down.

Well, your monetary ledger goes up. Your utility, your fulfillment from that latte might go up. I'm talking about the financial ledger. So I just wanted to ground-- when we talk about payment systems, think about it's really just a way to amend, usually, two parties ledgers'-- one going up, one going down. Now, in an earlier time, it was handing somebody a bit of gold or a bit of silver, and it was not recorded on central ledgers.

But we already live in an age of electronics, so this is really what a payment system largely is. It's not entirely. There's still some other ways to do finance.

So what were some early forms of payment systems that did just that, that moved and changed ledgers? They're called negotiable orders. I would dare say that most of you probably have not used negotiable orders of withdrawal that much in the last week or the last month. Has anybody here written a personal check in the last week? But in an earlier era, it would have been the whole class.

Anybody in the class not even have a checkbook? 3/4 of the class. Larry, how's that make you feel?

AUDIENCE: Old.

PROFESSOR: But a checkbook is, in essence, with a-- what do you put on a check? This is all about Bitcoin now. I'm not doing this just as a walk down memory lane for Larry and myself. What are the important pieces of negotiable order, withdraw, or a check?

AUDIENCE: Signature.

AUDIENCE: Put your signature on it.

PROFESSOR: So there's a signature. What else is there? I want to get to people I haven't talked to. In the back. I can't remember your name.

AUDIENCE: Me? I'm Dana. You put who you're paying to, how much, and what it's for.

PROFESSOR: All right, so there's a bunch. So a signature, a payee, how much, and what it was for. What else?

AUDIENCE: There's an account number and routing number.

PROFESSOR: Account numbers and routing numbers. So think about it. Account numbers and routing numbers is to say, in essence, what ledger is this coming from? And the payee is the ledger to whom it's going. And I'm sorry, Dan?

AUDIENCE: Also a date, and a day.

PROFESSOR: So there's a timestamp, a signature, a payee, the payor in the form of the account number, and an amount. Those five are really critical, and you'll find them all are going to be right in the middle of all this Bitcoin. And then the reason why you're-- you know, some other information.

I'm sorry, was there something else?

AUDIENCE: Kyle.

PROFESSOR: Kyle.

AUDIENCE: I just have a question. Would you consider something like PayPal or Venmo like a negotiable order?

PROFESSOR: They may be. They may be new forms. They're certainly parts of the payment system. They might not be negotiable orders to withdraw. They might not be a direct authorization for a bank with one ledger to move money to another ledger. They might be moving it on their own ledger. You're asking the right question.

So some early money that we already talked about that was ledger where the tally sticks in England and the Yap stone. These were ledger types and forms of money and was kind of interesting. So ledgers didn't just come with electricity and computers. So now let's get back to fiat currency, the heart of the earlier question. We already talked about it, so let's see how the professor did, because you already said some of the things that you said were fiat currency.

One, social and economic consensus. I'm in the school that it's just part of the history. It's not that different than everything that came, even though it built on that promissory note from China 700 years ago and the private bank notes and the goldsmiths in the 1700s. But ultimately, governments took control.

It represents central bank liabilities, and that's important. It's a liability of a central bank. It's not an asset. It's their liability side. But it's also-- guess what? There's a second form of money. And that's when you have a deposit in a bank, that's a liability of a commercial bank. Central bank is the top gold standard, in a sense. Using the word gold, but it's the top ledger. Commercial banks are like subledgers, in a sense. Please, Alan?

AUDIENCE: Sure. I'm not an economist or anything, but what does it mean for a coin or a note to be a liability of the central bank? What does that actually mean?

PROFESSOR: So before I answer, does anybody want to try to answer what it is? Eric?

AUDIENCE: Liability is basically an obligation to, in this case, pay someone an amount.

PROFESSOR: So because it's a social consensus, it's a very good question that Alan asked, is what does it

mean to be a liability of a central bank when it's just the currency in our pocket, right? This Federal Reserve note, this says Federal Reserve note on it. We can pass it around. I'm not afraid. It's only \$1. Right? If you want me to pass around 20's, then I want them.

But it says Federal Reserve note, right? So it's a liability of the commercial bank. In an earlier day, it said you could exchange it for gold or silver.

AUDIENCE: Right, so that's what I don't understand.

PROFESSOR: By the 1930s, for retail deposits in the middle of the Depression, President Roosevelt said, no more. You cannot redeem gold and silver. And then President Nixon, in the 1970s, said in the official sector that he was going off of the-- until that point in time, other governments could redeem in gold.

But when paper money started, it was not backed by gold. We had a period of the gold standard. We were on and off of it. We fell off of it during World War I. We went back on it. It would be a false narrative to say that we were on the gold standard for our first 140 years. I just wanted to clear that up. I mean, we sort of went on the gold standard, we went off, we went back on, and so forth.

But it is a liability on the books and records. So it is a matter of accounting in double-entry bookkeeping. I will show you in a minute the balance sheet of the Federal Reserve, and I'll come back to this question. Is that all right?

AUDIENCE: Can you clarify what is the bank liable for? So before, it gave me \$1, and I could go to \$1 and get back the gold, right?

PROFESSOR: Right.

AUDIENCE: Now, what are they liable for now?

PROFESSOR: It is, in essence, a social-- it's the first point. I'm going to separate it. The central bank is liable that they will move on its ledgers if you want to move that to somewhere else. So you could take that physical \$1 in and say, I want to deposit this in a bank. And they have to record it on the ledger of that bank. That is what they are-- and the US government, which is technically separate from the central bank-- or the UK government or the Chinese government. they're all technically separate from their banks-- People's Bank of China or the Bank of England.

Their governments are saying they will accept it for payments against taxes. So there's a set of social constructs. I'm going to just go through this to answer your question. It relies on a system of ledgers, and it's an integration of those ledgers between the banking system and the commercial banks. In the US, we have about 9,000 commercial banks. And what the Federal Reserve is saying-- but it's true about the People's Bank of China. It's true about the European Central Bank.

Each of these central banks are basically saying, if you bring your paper money in, we'll record it on the ledger of a commercial bank. And you can pay your taxes to our sister over here called the government. I'm sorry to let you down. It's not more than that. Sorry, Alan.

AUDIENCE: I have a potential answer. I might be totally wrong.

PROFESSOR: Please, no.

AUDIENCE: I think it's a legal and sustainable way to conduct a Ponzi scheme with a proper Ponzi scheme, where the value will increase by 1% to 3% if the central bank reaches the goal of inflation.

PROFESSOR: All right, any other points of view on that? I saw-- I'm not sure of your name. Oh, no, you don't want to say anything? No? All right.

AUDIENCE: I think I'll go back to point one. It's a construct that someone would give you something. So your dollar with the central bank, the central bank owes you that dollar's worth of whatever you desire. And someone will happily take that dollar from the central bank and give you the goods that you want. So it's a roundabout way of-- it's a way of transacting something, whatever value that dollar has.

AUDIENCE: It's also central bank liability, because whenever the government has sovereign debt, it can't just issue new notes. It's liable. So that's why it's a liability, because you can only issue notes against a certain amount of reserves that you carry. So that's why you refer to it as a liability. Because you can't just issue new notes whenever you need them. You can't just make new money out of thin air. So you're liable for every new note.

PROFESSOR: I'm going to take one more comment on this and then give a couple more things. Eric?

AUDIENCE: The currency is actually a small part of the total reserves of the Federal Reserve System. I think maybe the bank reserves are maybe a more applicable application, because a bank can actually require the Fed to print money by making more loans. So in that way, there's this

mechanism to ensure that liability [INAUDIBLE].

PROFESSOR: I'm very pleased with this discussion, even Alan's contributions about the schemes. This is the debate. If Jay Powell were here-- how many of you know who Jay Powell is? Who's Jay Powell?

AUDIENCE: It's a lab.

PROFESSOR: Jay Powell. No. Who's Jay Powell?

AUDIENCE: Head of the Federal Reserve.

PROFESSOR: Head of the Federal Reserve. Thank you. Sorry. But if Jay Powell were here, he'd have a laugh along with what Alan just said, but he would say, also, the liability is a social liability, as well. That a central banker, to their core, believes what they are trying to do is ensure for the stability of this social thing we call money and to make sure that it doesn't get debased and it has some value.

So it's accepted for taxes, we talked about. Notes and coins are legal tender for all debts, public and private. I walk into a Starbucks and I say, I'd like a cup of coffee. Here's my \$5 or whatever it costs these days. Does the person behind the counter have to brew the coffee? Is just a yes or no? Can I see? Who wants to go for it? There's a no from Christopher. What, Chris? There's a no from Chris. Who agrees with Chris? OK.

They brew a cup of coffee. I go to the other side of the counter. The coffee's sitting there. Now, do they have to accept my \$5 at that point? Yes. Before they brew the coffee, nobody has to take dollars. But once a debt is established, they've produced the good, they've provided the service, they have to take it. Just a small, little thing. That's what legal tender is.

And so there's many establishments around the globe that are basically now putting little signs out, we don't take Swedish krona. We don't take this. We don't take that in paper form. They'll still take it electronically. And there's a new little bit of definitional thing going on about legal tender. There's also some unique tax treatments, but I'm not going to go through the currency.

So central banking and money we talked about a little bit. This is a kind of chart that I borrowed from somebody else's paper. But the central banks at the top is at the center. And if Alice and Bob-- and we'll be talking about Alice and Bob in Bitcoin time, so you can pull this chart down later-- want to transact and they're at the same commercial bank, Bank Number 1,

then commercial Bank Number 1 has to change their ledgers, moving money from Alice to Bob.

In essence, if you're both two people at Bank of America, you can move your balance at Bank of America. But if you're at Bank of America going over to Citicorp, then something has to go between two ledgers, Bank of America's ledger and Citicorp's ledger. And the only way to transact between two banks' ledgers is some balancing act has to happen at the top ledger, called the central bank.

And later, when we talk about payment systems-- and I'm going to use this slide again later in the semester. That's why I'm not going to spend as much time now on it. We're going to talk about ledgers. And when you move money between two banks, it's all within one closed system-- that country's or that society's central banking system. But then it gets really a little bit more iffy and woolly when you're moving from one currency to another currency. Because how do you make two closed ledger systems operable? Not for today, but we'll go through that later when we do payment systems and the like.

The central bank, the US central bank-- this was the only good slide I could find, which was about a year old. Its liabilities and assets are about 4 and 1/4 trillion dollars, \$4.3 trillion. \$1.7 trillion of that is in currency. Do I get my \$1 back, by the way? I mean, my liability. So \$1.7 trillion of those greenbacks are in circulation. And remarkably, even though half of you probably don't use cash that much, you don't even have checking accounts, the amount of cash in circulation is growing faster than the economy in most developed nations.

Why do you think that is? What probably one word?

AUDIENCE: The amount of 2008 crisis [INAUDIBLE].

PROFESSOR: Oh, that's more than one word.

AUDIENCE: Trust.

PROFESSOR: Drugs.

AUDIENCE: Trust.

PROFESSOR: Oh, trust. I thought you said drugs. Trust. Well, it does have to do with trust, but it also has to do with drugs. Paper currency is a wonderful method of money laundering, drug running, and

a store of value. So there's certain segments of our economy and segments of the worldwide economy that does not want to be in the electronic banking system.

I'm going to slip through these quickly, but there's another piece that we need for this whole class and for the semester is credit and credit intermediation. But just a little thing-- credit cards started only 60 or 70 years ago, but they go back to a book a little over 100 years ago. The word "credit card" is used 18 times in this book, where a science fiction writer in 1887 said, what would the world be like in the year 2000? And it was the first use of the word "credit card."

And he said that society would have a form of money, and you would have credit against it. And it's a fascinating thing that somebody could be that visionary. But there were merchant cards starting, so maybe he wasn't so visionary. Oil companies in the 1920s, charge cards were starting, but they were single-merchant cards. You could have credit from that merchant.

In 1946, in a bank in Brooklyn, a guy named Biggins started with that. That was the first real charge it. You could charge things in a few dozen places in Brooklyn, literally. And then, all of a sudden, it took off. Diner's Club started in the early 1950s. They found that they could get a bunch of restaurants to say, wouldn't you want to extend credit, and we'll back it? American Express in the mid-1950s.

And then, finally, in the mid-1960s, Bank of America, which at that time was a California bank, figured out they would create a co-operative with a bunch of other US banks to extend credit. And the credit boom took off. And what was interesting, the laws to regulate all this didn't come until the 1970s, at least in the US-- the Fair Credit Reporting Act and all the other laws. There's three big ones in the 1970s.

I go to conferences sometime and talk about Bitcoin regulation, and they say, well, why can't the government solve this now? I sort of remind them that it took 15 to 20 years from the introduction of credit cards kind of in the early to mid 1950s and the real take-off in the 1960s-- it was 1974, 1970, '77, the three big credit laws. So if you're going to be an entrepreneur in Bitcoin, know that it could be 15 years until there's some cryptolaws in the future.

That was the processing machine from the 1950s. I made it too small, sorry. Visa made it better. And then, of course, that's what we all see today, how your cards get processed.

So the role of money we've talked about. So I'm going to skip over that. But now the

characteristics of money. What makes a good money? We talked about some of this earlier. It's durable, meaning that that salt cube wasn't the greatest, because if a lot of rain came, that would wash away. Gold and silver, metals, are durable. They're portable.

The heavier it is, the less portable it is, and that's why gold was a better money than silver. You could move it-- and better than copper and bronze. It was divisible easily. You could slice things up. Uniform and fungible. And anyone who's who down the rabbit hole on this stuff, if you really want to learn about money, read about *Crawford versus Royal Bank* in 1749.

There was a gentleman at the early part of paper money that mailed two 20-pound notes, and he wrote his name on them. They got lost in the mail, and he took the banks to court to say, those were mine, when they were found. And there was no law in Scotland or in England at the time as to what to do about it. But if you lose or somebody stole a piece of art, you get it back. And the law was settled in 1749 that you actually don't get your money back.

Does anybody want to guess as to why the courts-- it was a matter of first interpretation. The courts had no jurisprudence on this before 1749. Why did the courts decide that a piece of art was different than currency? And it goes to the fundamental of what money is, fiat money is. Anybody want to take a guess as to why the courts-- they could have gone the other way.

AUDIENCE: How could you tell if someone really owned money? How could you [INAUDIBLE]?

PROFESSOR: He signed it. Actually, the facts were clear it was the currency he signed. I'm just helping you out so that-- that's a good point, but he signed it.

AUDIENCE: It can't be used as a medium of exchange if it doesn't belong to the person [INAUDIBLE].

PROFESSOR: In essence, if you were to go back and read-- there's some history on this, and read the court cases. This was the point. The court basically said, we have to make this a medium of exchange, the greater social good. It has to be fungible. And the Royal Bank of Scotland was, of course, kind of closer to the courts than this gentleman, Crawford. But the banks were also saying, we can't keep track of this. So it was a mixture of the two, but it made it fungible. Eric?

AUDIENCE: Was it those specific notes that he had signed [INAUDIBLE]?

PROFESSOR: Yeah. Yeah.

AUDIENCE: [INAUDIBLE].

PROFESSOR: And in 1749, they all had serial numbers, and they were signed in a way that not today. Of course, they're acceptable, and they're stable. And we're going to talk a lot about the last point. They're stable because they're hard to mine, and Bitcoin has that embedded in it, as well.

The design of money is really important, as well. You can make it a token-- a token is like something physical-- or account based. We're of course now living in a world of account-based money, and it's digital, not physical. It can be issued by the private sector, just like banknotes in the 18th century, or private sector like Bitcoin, or it can be central.

It can be widely acceptable or just wholesale. There are forms of wholesale money. One of the biggest forms of wholesale money is the central bank's reserves are only available to the commercial banking system. We're going to study this money flower later, but I put it in the slides because this-- I didn't create this flower. You have a reading later in the semester from the Bank of International Settlement that has this money flower in it.

But it's basically across these four things-- is it token our account based, physical or digital, private or central, or widely accessible? And then all monies fall into one piece of this money flower. There's a Professor Garrett that came up with this flower, and there's an optional reading later in the semester from him.

You had a reading from Clark. There's not enough time, but all this stuff failed. Does anybody want to give me a flavor for one or two reasons why a bunch of digital cash failed? Did anybody read the Clark reading, the history of some DigiCash? Oh, Alan read it. Anybody else read it? Over here. I can't remember--

AUDIENCE: Zhan.

PROFESSOR: Don. So what did you--

AUDIENCE: Zhan.

PROFESSOR: What?

AUDIENCE: Zhan.

PROFESSOR: Zhan. Zhan, what did you take from the reading? Why did these all fail? What's the one or two biggest reasons they failed?

AUDIENCE: Most of them still relied on kind of some form of a central authority.

PROFESSOR: All right, they relied on central-- DigiCash certainly did it, David Chaum's case, and some of the others. Any other big reason? Alan, did you have--

AUDIENCE: There wasn't enough adoption by merchants, I recall.

PROFESSOR: Definitely not adoption by merchants. Very good. Third reason why they failed? One that's at the core of what Bitcoin solved.

AUDIENCE: Incentivizing like a decentralized network to keep that ledger, maintain the ledger.

PROFESSOR: All right, incentivizing the ledger. Behind Eric.

AUDIENCE: They couldn't solve the double spend problem.

PROFESSOR: That's it. Couldn't spend the double spend problem. Could a currency be spent not just once, but twice? So there's four things that were raised. Four things about centralization, the double spend. They couldn't get merchants to adopt it, and there was couldn't-- some form of consensus as to what the ledger was.

I'm going to flip through these quickly, but digital and mobile money did happen. We were asked about PayPal earlier. It was 1998. In Norway, Ericsson and Telenor had the first mobile app. And it was to get movies on your mobile phone. 1999, Alipay comes along that we'll talk a lot about when we do payments later.

And of course, M-Pesa that we talked about a little last week in Kenya, where Safaricom noticed that a bunch of money-- near money. It was mobile minutes that was being used as money in Kenya, and now there's 20 million users of that. And of course, there's a bunch of regulations now and so forth.

Starbucks started in 2011. And then, of course, it's now off to the races in mobile money. One of the key things about mobile money we will discuss and learn together is the question each one of these is, where is the stored value? And I have to tell you, sometimes I get quite confused when I research a new app. Are they storing the value? Or are they just a processing provider to move-- as we said earlier, payment systems move and change and amend other ledgers.

In a number of these, like M-Pesa, initially they were storing the value. And mobile apps

Starbucks stores the value. But many of them are just applications, computer code, to move the ledger somewhere else. But the riddle remained. You remember that riddle-- how to move money peer to peer without a central authority. And that's what I'm asking for next class, Thursday, to actually read.

I wouldn't wing it, and I wouldn't be afraid of it. Satoshi Nakamoto wrote a paper that everybody in this class-- if you're at MIT, and a few of you are at Harvard. I'm telling you, you can read it. You'll understand maybe 1/2 to 2/3 of it. It's not deeply technical. And it's only eight or nine pages.

I've also assigned National Institute of Science Technology, about 20 pages of reading from NIST. The question is whether that's Bitcoin. I'm going to skip through the study questions, but the study questions are really about cryptography and how append-only timestamping. We are going to get into the nitty-gritty over three lectures. I couldn't commit the whole course, the whole semester.

But I think three lectures-- Thursday and the two next week. Anytime you want to come to see me-- Sabrina is somewhere here on the floor, who's one of our TAs, who's a computer science master's student and knows more about all of this. Madores, who was here last week-- I don't know if Madores is here, who's part of the Digital Currency Initiative.

Over three lectures, we're going to try to work through what's the cryptography, and why does that matter? How does the time stamping happen? How's this look like money, and how are the transactions kept? Yes? You get to close it out, almost.

AUDIENCE: Can you just answer the question posed about the longest running blockchain?

PROFESSOR: I can answer that, but the assignment was to answer it by Thursday, right?

AUDIENCE: Oh, Thursday. OK.

PROFESSOR: So by Thursday. What's your first name?

AUDIENCE: Caroline.

PROFESSOR: Caroline. Did I say I was going to answer it today?

AUDIENCE: [INAUDIBLE].

PROFESSOR: Oh, did I say today? No, is there a mutable record of what I said? I'll answer it now if you want. Does anyone have the answer in the whole class?

AUDIENCE: Yeah. It's a service called Surety that Gillespie begun working in 1995, was a timestamp service for digital documents. And the way they did it was use a hash function to create a seal with a timestamp on the document. And then present the weekly batch of seals. And they actually published it in the *New York Times* [INAUDIBLE].

PROFESSOR: So Caroline, it's good to raise the question. I thought it was for Thursday, but thank you. Stewart Haber, a cryptographer, and a colleague at Bell Labs in the early '90s, said, how do we notarize information, digitally notarize? And we're going to be talking about this Thursday a lot. They used a cryptographic method called hash functions. And they were just trying to notarize information.

And by 1995, they took-- they were entrepreneurs. They created a company called Surety. And once a week, they published, in the *New York Times*-- and they still do it. You can get a *New York Times*-- I believe it's on Saturday or Sunday. And they take-- it's in the classifieds section. And they have the hash function, which you'll read about between now and Thursday.

They have the hash of all the pre-existing information. And so they timestamp it by using the *New York Times*, and they use cryptography. And it's currently 23 years in running.

AUDIENCE: So that's the longest in terms of time, not the longest with how many ledgers or how many--

PROFESSOR: Correct, because Bitcoin is about 550,000 blocks, and this would be whatever 23 years times 52 is. Longest in time. Thank you. I look forward to seeing you.