

1. **CI: The
Frontiersman
and the Dany**

Draw the contraption (Aparat) that Joseph Henry built with his students

- contraption = electromagnet
- they built a huge electromagnet
- coil of wire around a piece of iron, attached to a battery
- they were able to lift up to 1500 pounds.

How does a telegraph work?

- You heard a sound, when the electro magnet was powered up by the battery
- he lengthed the wire that stretched from his battery to the electromagnet
- turn on the battery and a current ran down the wire, the electromagnet powered up, and it pulled the castanet (Kastagnette = Klapper) toward itself. You heard a click when the switch turned back. they also replaced the castanet with a bell.
- they had to agree which arrangements of click represent which letters

How did the telegraph change the world?

- Everything got interconnected
- Samuel Morse (ex painter/artist)
- no horseman are needed anymore. information is transportet over the wire (instantly)
- time can be synchronized between cities

Discuss Bodanis' statement that the telegraph was "a nearly form of globalization"

- it was possible to synchronize information instantly
 - milions of farmers were forced to take on last names to enlist them for taxes.
 - movement of armies were coordinated by telegraphs
 - newspapers started to retrieve information of foreign correspondents
 - diplomats negotiated with telegraphs
 - more jobs were available
 - train schedules got more accurate
 - people were able to make the arrangements to move to other countries (Europeans to America)
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2. **C2: Discuss the following quotes and put them into context**

Aleck

and

Mabel

- "[Alexander Graham Bell] was driven neither by avarice (Habgier) nor by the urge for power" (p.28)

His invention came because he was in love, with one of his students. The girl, called Mabel, was seventeen and deaf. (taub)
Her parents forbid that they can meet. So Bell realized that maybe with a great invention he could gain the respect of the parents.

- "By the early 1870, when Aleck had arrived in America from Britain, it seemed possible to send more than one signal over a standard telegraph line" (p.29)

Send two signals simultaneously with different frequencies. They overlap in time, but you can distinguish them.

- "He had grown up in a family where understanding how sounds could be communicated was central to every daily task." (p.31)

Bells mother had been unable to hear. Bell realized that simply making long lists of all possible sounds was never going to help a deaf person. The Visible Speech kit, was a collection of diagrams, showing different positions of the tongue and lips.

In 1875 Alec Bell took an apparatus he had built to the now aged Joseph Henry. Describe the apparatus in your own words or draw it. (p.30)

It was an electric wire stretching out from a battery and connected to a single tuning fork. By switching the battery on and off, he could make the tuning fork hum in various ways.

Describe the "artificial throat and lips" that Bell and his brother had created as teenagers. (p.35)

The tongue was made of several small coated paddles (beschichtete Paddel) and behind it they had put the larynx (Kehlkopf) from a dissected sheep, and below it they had attached a bellows (Blasebalg).

At the time, several researchers were trying to invent a "telephone". In what way was Bell's approach different?

Describe his telephone experiments on p.36.

He recognized that he has to transform the shaking parchments (Pergament) into electricity. So he made this key observation, that electric charges pouring out from a battery are always at a steady rate. But if you bend or twist the wire, the electric current can't pour through so easily. (increase the resistance inside the wire) Each time he spoke, the parchment was pushed against the wire, creating a resistance.

How does a telephone basically work? (p.36/37)

You speak into a microphone, which quivers (zittert) from yours voice uneven air blasts. The quivering microphone leads a wire to send an electric current surging along in an exact copy of that uneven pattern. Everything happens in reverse at the receiver. It even transmitted the volume of the sound (whisper)

3. **C3:** **What were "technological mercenaries", who employed them and to what purpose? How does the scenario relate to Edison, Orton and Bell? (p. 40)**
Thomas and J.J technological mercenaries are people who copy a device using a slightly different process. (a.k.a patent-breaker) they are bankrolled (finanziert) by rich financiers (Mr. Orton) who want to oust (verdrängen) competitors (founder).

What "flaw" did Bell's telephone technology have and how did Edison improve it? (p.41)

Bell's invention had a problem with the distance. You had to yell and the signal often died or became too feeble to hear. Edison attached a stronger battery, which pumped a strong steady electric signal through the wires.

Explain why "for decades researchers had dreamed of making a practical artificial light, but no one had come close to succeeding." (p.42)

No one knew how to heat up the metal so long that it glows white, but without melting.

How did Edison attempt to solve the problems (list several attempts) And how did he eventually succeed? (p. 43-46)

- Edison considered platinum as the first metal (very expensive)
- Heated nickel wires (light was too strong and burned out too fast)
- He created light bulbs, which surrounded the metal with little vacuum, so that no oxygen is able to get to the metal. (so they do not burn) -> they still burned down
- Then he tried fragments of cork, and then cotton threads (which was promising)
- Japanese bamboo (geometrically parallel fibers)

Discuss the following quote: "Transferring information faster shrank the globe, just as the lightbulb shrank the night." (p. 47)

- With light, the night is now not as long as before.

How does the electric motor basically work?(p.48/49) Make a drawing.

- Imagine a clock with just a single long minute hand, which toggles between the three o'clock and nine o'clock position, because of an electric magnet (110 times a second)

What impact did the invention of the electric motor have on urban development and society? (p. 49 / 50)

- Land prices were high, so it made sense to build vertically. Electric elevators helped to build that way.
- Electricity was also used for amusement parks and many other places
- Electricity was also used for small machines helping in domestic work (cleaning, carrying, washing)

Discuss the following two quotes: "[Edison] was supposed to be the greatest electrician of his age, yet he didn't even know what was happening inside an electric wire." - "Edison was puzzled by the dots." (p.52)

- He was an engineer and let the fancy professor work out, what really happened within the wire. Even though he tried to find out what really happens, he stopped, because he was working on so many other things at that time.

What did J.J.Thomson discover?(p.53)

- The electron (he weighted flying particles)
- Atoms were not solid little balls. Rather, parts of them could be torn off. The torn-off bits (electrons) could bounce and skid forward, like smaller balls, within any open channel that lay ahead of them.
- Those torn-off bits (electrons) roll forward inside a wire, creating an electric current

Watch the following two audiovisuals about Edison and compare them to each other and to chapter 3.

- <http://www.youtube.com/watch?v=ZlxVDdBtFQQ>
 - http://www.youtube.com/watch?v=kyso7_HetyM&feature=related
-

4. **C4:** **Discuss the following quotes: "Faraday had one great advantage over his rivals in England and on the Continent. They had all been trained in the advanced mathematics that Sir Isaac Newton had developed in the seventeenth century." "Their universe was basically empty." (p. 62 / 63)**

**Faraday's
God**

- because of his religion, he thought that the space is not empty
- he was not a traditional scholar -> he thought differently
- Newtons science was a image of a cold, clockwork universe, where planets rolle along like giant, separate billiard balls with own gravitiy fields.
- They assumed, that gravity did no permeate (durchdringen) the void between the planets.
- Faraday however, always thought for himself and was never seduced by the beauty of Newtons equations.

What was the connection between Faraday's experience in Switzerlandand" what he believed of science". (p. 64)

- There was an ordinary rainbow at the base of a waterfall, just visible when the wind blew in the right direction.
- Even when space seemed empty, something was there

"There in his cold basement laboratory at the Royal Institution, Faraday had shown that "what? explain what Faraday had shown and what Faraday's experiments suggested. (p. 66 / 67)

- he created a electro magnetic force field, by moving a magnet toward a coil of wire, which produced a electric current
- that is only possible if the space between them is not empty
- our universe is filled with millions of these invisible flying for fields

Who was Ada Byron Lovelace?What do we find out about her from the following audiovisual?

<http://www.youtube.com/watch?v=xiZozgCLHc4>

- She was Lord Byrons daugher and countess (Gräfin) of Lovelange
 - She worked on early notions of computer programming. She published the first computer program
 - Ada added her own notes on the topic of the analytical processor (computer predecessor)
 - a method for calculating a sequence of bernoulli numbers
 - in the paper published at 1843, she stated that such a machine could be used for creating complex music and graphics.
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5. **C5:**
Atlantic
Storms

Who was Cyrus Field?

- He was retired, but did not feel that way
- He had a vision of connecting two continents with telegraphs, because he thought that it is annoying if two continents are separated.

Who was William Thomson and what was special about his theories?

- He was a scientist and mathematic at Cambridge, who took Faradays vision very seriously
- Cyrus Field knew Thomson, because Thomson had been making a study of undersea cables that were already in operation.
- he noted several flaws, if information was transmitted over longer distances. The signal was no longer sharp and clear when emerging.

Draw the original cable design of Field and explain why Thomson thought it is unsuitable. (p. 77)

- three layers: each was as thin as possible to save weight. There would be a thin copper at the center, a thin layer of rubbery insulation around that and finally a casing of iron to protect the cable from ripping off.
- he thought that the signal would disperse over all three layer and finally get lost in the sea.

What view did Edward Whitehouse have about cable design and why did he get to work with Field? (p. 79)

- Edward did not believe in preposterous invisible flying force fields
- He thought, electric charges just shot out from the metals inside a battery and poured down the wire
- Whitehouse misled Faraday, to claim that Thomsons approach had flaws. Soon people started to buy shares of the company, which resulted in enough money, to fund everything.

What was the initial reaction in New York and London when the first cable had been laid? (p. 82-83)

- There was a lot of excitement, and they thought that the technology is conquering the planet

When it became clear that the cable didn't work well, how did Whitehouse want to fix the problem? (p. 86)

- He tried to send stronger currents through the cable, with a even bigger battery. but the the cable heated up, and the insulation melted.

How long did the cable operate until no signal could pass any longer? (p.86)

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What happened when Cyrus Field made a new trans atlantic cable with Thomson's design? (p. 87/88)

- The improved cable snapped on two-thirds of the way and it was impossible to fix it (too deep water)

What happens at the levels of electrons when you telephone someone (landline)?(p. 88)

- you are sending an invisible force field, which shakes the electrons that are already waiting in your listeners phone.

What did James Maxwell discover about electric fields? (p. 90/91)

- he discovered that the force fields were actually made of two parts: an electric part and a magnetic part
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6. **C6: A
Solitary
Man**

When Heinrich Hertz started to experiment with 'wave machines', whose theories did he want to examine? (p. 99)

- Maxwells predictions

Draw the apparatus which Hertz constructed to test the wave theory! Describe how difficult it is to make the waves visible. (p. 100)

- Hertz oscillator was divided in two parts: The first was a transmitter, where an electric spark jumped back and forth between shiny metal balls. The second part, the receiver, was a hanger. (Kleiderbügel)
- if the invisible waves would fly to the hanger, they would produce yet another spark.

What was Heinrich Hertz's next step in his investigations?(p.103)

- Hertz increased the distance between transmitter and receiver.
- the transmitter stood at one end wall
- the opposite end wall had been turned into a mirror for electric waves.

What did he manage to show in his experiments with solid conducting walls?(p.105)

- He was able to send the signal over a larger distance by means of concave mirrors

Which scientist continued to investigate the 'Hertzian waves'?(p.110)

- Marconi

Which example was given of early naval (ship) communication with radiowaves?(p. 112)

- Help message of the titanic: "SS Tinanic ran into iceberg. Sinkng fast"

*How did radio transform society in the field of (1)business,
(2)culture and (3)politics? (p. 113/114)*

1. introduce the Radio Music Box (radio waves, on different wave lengths). If only one million families thought well of the idea, it would yield (abwerfen) considerable revenue.
 2. Radio reached a lot people, even though individuals thought they were being aimed personally. (advertising, cult of celebrity, sport fan base)
 3. Hitlers propaganda: The larger the mass of men to be reached, the lower its purely intellectual level will have to be set
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7. **C7: Power in the Air**

Discuss the following quote and put it into context: "A contact there asked him if there was any truth in the rumor that evil death-rays could be sprayed from radio transmitters at an aircraft." (p. 118)

- Basic answer: Radio waves are too weak to damage a hulking aircraft (they don't carry enough power to melt the plane or injure the pilot)
- Watson Watt was not fame or rich, so he decided to work a better answer to the question.

How does the effect of radio waves hitting a human body or rock differ from the effect of radio waves hitting metal? (p. 120)

- To radio waves the human body is invisible, because the electrons are generally held pretty tight
- The atoms in iron or aluminium are more loosely constructed. -> signal is reflected.

What consequences did this have for air planes and warfare?(p.121)

- If you send a radio wave in the direction of a plan, trillions of electrons could be made to ripple in unison (Einklang) and serve as tiny bubbling radio transmitters of their own.
- is the transmission powerful enough to detect? (first idea of a Radar)

What alternative methods had been used to detect enemy planes?(p.123)

- The placed blind people with excellent hearing where possible enemies might emerged
- They use a giant concrete ear

What did Watson Watt mean when he said "Britain has become an island once more."? (p. 124)

- Britain is able to protect themselves. Britain was a island, so it was difficult to invade them.

What does radar stand for?(p.125)

- "Radio detection and ranging" (later "Radio Direction Finding" was used)

Make a drawing of what happened when the Graf Zeppelin approached Britain in 1939. (p. 127)

- Zeppelin were coated with shiny aluminium varnish.
- It formed a perfect target, suspended conveniently high in the air
- But most of the high masts of the radar stations (Chain Home) stayed quiet
- They sent it to spy (explorier mission, to probe Britains defense)

Put the following quote into the context of World WarII: "In hospitably, the reception committee turned all these overseas visitors away." (p. 129)

- The german though that they were unobserved, but when they reached the english airspace, ten RAF squadrons were waiting for them.

Explain the following quote: "Radar so far had been the hero - a protector of the nation. Yet once Britain learned how Germany was catching up, it would become a villain (Bösewicht)." (p. 131)

- The germans were not just catching up with the British in their use of radar, but surpassing them.
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8. **C8: Power unleashed**

What was the difference between German and British radar systems in WWII? (p. 134 / 135)

- The German system was much smaller (five feet or less)
- The German radar used different ranges, so it was more precise
- The German radar setting was very hard to change

What military operation did the British plan to deal with the "Würzburg"? (p.135-137)

- They wanted to steal the radar to examine it
- Cox had to join the paratroopers, to supervise the disassembly of the radar.

Draw a timeline or "flow chart" of the operation that took place on February 27, 1942. (p. 137 - 139)

1. Troops landed in France with parachutes
2. They moved to the radar station
3. They captured the radar operator
4. They fought against German resistance, which wanted to prevent the British troop from stealing the Würzburg
5. The navy evacuated the troops
6. Cox was taken on a speedboat, and Spitfires gave cover.
7. Cox was given a fast motorcade ride to London

What was the weak spot of the "Würzburg"? (p.141)

- Its settings were very hard to change

How did "chaff" work?(p.142)

- A large number of aluminium stripes, were dropped from an airplane to confuse the radar operators.
- They knew the ideal wavelength of the radar and were therefore able to work out the ideal size for the chaff.

What was the role of Jones, Cox and Harris in chapter 8?

- Jones: He realized that the Germans have a functional radar system as well
- Cox: His experience as an amateur radio operator, qualified him to disassemble the Würzburg radar.
- Harris: He ordered area bombings on German cities, to kill as many people as possible.

Very briefly describe the Hamburg firestorm and the science behind it.(p.146f)

- The British bombers used chaff to get near the city of Hamburg under cover and then release the chemical incendiaries. (Brandbomben) They heated the carbon (coal) in Hamburg's wooden homes so much that they exploded.

What are "quantum jumps"? (p.151)

- The ability of electrons to dematerialize; they can pop through space and be made to start and stop in fresh places.
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9. **C9: What was special about Alan Turing's solution to the mathematical problem of David Hilbert? (p. 161)**

Turing

- It was a machine, that was theoretically able, to solve any problem that can be translated into simple logical steps.
- the machine operator would have to write down the instructions the machine had to follow. the machine did not need to know what those instructions meant it would simply execute them.

Why couldn't Turing build his electrical thinking machine at the time of the 1930s? (p.163)

- The telephone switches were far too big for Turings purposes.
- The machine would need thousands or more of simultaneously operating switches.

Where did Turing work during WW2 and what was his job there? (p. 165)

- He was a Code Breaker at Bletchley Park
- He cracked the Enigma machines, which much of the German army used to encode their messages.

What was the name of the machine he designed there?(p.168)

- Colossus

Which problems did Turing face when working in Manchester after WW2? (p.171-2)

- The engineers in London did not appreciate the help of Turing, because Turing was different (

What was the tragedy of Alan Turing's life?

- He was attracted to men
 - He had to agree to an experimental treatment with female hormones to cure his homosexuality
 - As a effect, he could not concentrate
 - He body changed so much, that he could not live with it, so he took his live. (with cyanid)
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10. **C10: Turings** **Why can you see through glass but not through steel?(p.177)**

Legacy

- light waves get soaked up, because metal atoms have many free outermost electrons.
- Glass electrons, by contrast, are much more tightly bound to their atoms.
- all substances in the world are divided into two quite different types: conductors (steel or copper, that could transmit an electric current) and insulators (glass or wood, that cannot)

Scientists believed until the 1940s that there are two types of materials, conductors and insulators. But there is also a third type. Which chemical element is it and where is it found? (p. 178)

- Silicon, which is a semiconductor
- On much of the surface of our planet

What is the technical name for the third type of material?(p.179)

- semiconductor

Who were the two scientists who managed the break-through in the fabrication of the 'atom-level on/off switch' and what was the name of their laboratory? (p.181)

- Bell Labs
- Walter Brattain and John Bardeen

They could make electrons start flowing and they could also make them stop -> atomic on/off switch

How does their work 'tragically' relate to Turing? (p. 176, 181)

- Turing had sought for this invention. He never found a proper element, even though it was right under his nose.

What was one of the first practical applications for the transistor?(p.183)

- Hearing aids (devices to help the deaf)

Who was William Shockley, and what role did he play in the history of silicon valley? (p. 185)

- Shockley was jealous of Brattain and Bardeen.
- Although he improved their initial ideas considerably, he tried to take credit of all their work.
- He thought that his children and wife were inferior to him. (minderwertig)

Who did William Shockley attract when he founded his business in Stanford, California, and what did the young scientists do when they got to know him better? (p. 186)

- The most skillful engineers and physicists wanted to work with him
- The bright people quickly bonded with one another when they realized how awful he was and kept those bonds and created their own companies in the area (Silicon Valley)

What was the impact of the transistor on the invention of new technologies? Which devices are based on the transistor (Name at least 5!)? (p. 187-188)

- Cell phones
 - Weather satellites / spy satellites
 - GPS
 - Digital cameras
 - Solar Cells
 - Email and Internet
 - Credit Cards
-

11. **C11: Wet Electricity** Put the title of the chapter "Wet Electricity" into context.

- from physics to biology
- It seems odd, that inside our wet body, there is electricity.

Answer the author's question on p.201: "what are live electrical circuits doing embedded in our bodies and brains?"

- they stimulate nerves
- Anything that lets the sodium booster in will start a signal
- In a eye peering at a computer monitor, the incoming electric wave from the screen hit molecules known as rhodopsin, which exist on the retina.

How is it possible that there is electricity in our bodies?(p.203f)

- Sodium atoms have one more positive charge in its own center than it has negative charges in its remaining electrons.
- Any atom that has a different number of electrons than it normally starts with is called an ion. This is what our bodies use to carry the currents.

Describe Hodgkin's and Huxley's squid experiments.(p.205f)

- they stick a thin glass needle right down the middle of the squid nerves to measure the electricity inside the nerve and compare it with the outside.

Discuss the following quote: "Nerves have to work differently: They can't pour their electricity straight down the middle of their axons, as Alexander Bell had imagined electric sparks rolling down a copper wire in his telephone." (p. 208)

- ??

What is the role of sodium in nerve impulse transmission?(p.206-211)

- They keep a nerve signal going
- Further research showed that potassium ions are also central to nerve conduction

Explain the effects of cold temperatures, nerve poisons, alcohol and anaesthetics on our body.

- they slow the nerves down
- they block the sodium channels

12. **C12: Electric Moods** How can a signal cross the synapse between two nerves?

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Describe the experiments that Otto Loewi carried out in order to answer the question above. (p. 216)

- kill frogs and cut out their hearts. He would keep one heart attached to the nerves that poured their unknown chemicals down on the heart
- then collected the unknown nerve chemical and poured it over another heart. If the second heart reacted in the same way, then he would know that something in that liquid carried the answer.

Describe the functions of different neurotransmitters and why they are necessary in our system. (p. 218)

- Adrenalin: speeding up the cells it reaches
- Adenosine: Slows down the firing rate of brain cells.
- Endorphins: Good moods are more long lasting.

Describe how coffee affects our system.(p.219)

- Caffeine slips into adenosine docking sites. With those gaps now filled, the adenosine can't go in.

Explain the role of neurotransmitters in the treatment of mood disorders such as depression.(p.221)

- Serotonin: is important in setting our moods. Low amounts of serotonin in the brain, often feel depressed
 - If someone is not producing enough serotonin, or if their receptors for it are not working well, they try to slow down the demolition and reabsorption process.
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13. **Summary**
1. Electrons can bounce along inside a wire; that insight led to telegraphs and telephones and lightbulbs and electro-motors
 2. A hidden force pushes electrons along within the wires and when shaken hard enough, the force can even vibrate as a wave that flies free from those wires. the result was radio, radar and cell phones.
 3. Quantum theorists found that electrons could teleport in great leaps and even be forced to remain in seemingly immovable states of low energy. the result was switches that are used in computers
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