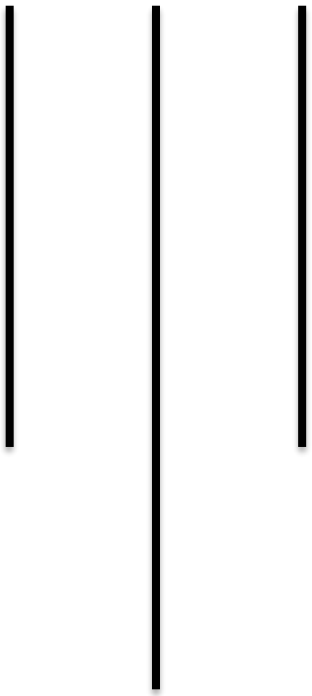

DELHI TECHNOLOGICAL UNIVERSITY,
(DTU) DELHI

A CASE STUDY ON
CHERNOBYL DISASTER
April 26, 1986

Submitted by: Ayush Karn & Keshav Rajak
Roll: 2K19/CO/454 & 2K19/CO/187
Course: FEC-07 S1-G1 EVS
Submitted to: Ms Sakshi

DECLARATION

We hereby declare that project report entitled "A Case Study on Chernobyl Disaster "submitted by (**Ayush Karn & Keshav Rajak**) to Delhi Technological University (DTU), Delhi is a record of original work done under the guidance of Ms. **Sakshi** for the course of Environmental Science EVS (FEC-07).

Name: Ayush Karn & Keshav Rajak
Roll No: 2K19/CO/454 & 2K19/CO/187
Submitted to: Ms. Sakshi

CERTIFICATE

This is to certify that Ayush Karn and Keshav Rajak of Computer Science and Engineering Department (COE) having Roll No 2K19/CO/454 & 2K19/CO/187 respectively have successfully completed the project work entitled "A Case Study on Chernobyl Disaster" on Environmental Science (FEC-07) for Fourth Semester which is to be evaluated as the Mid Term Component.

Signature: Ayush Karn & Keshav Rajak
Date: 28-04-2021

ACKNOWLEDGEMENT

We would like to express our special thanks of gratitude to teacher Ms. Sakshi as well as our college (Delhi Technological University, Delhi) which gave us the golden opportunity to do this wonderful case study on the topic "A Case Study on Chernobyl Disaster", which also helped us in doing a lot of Research and we came to know about so many new things. We are really thankful to them.

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Chapter 1

Introduction

The **Chernobyl disaster** was a nuclear reactor accident in the Chernobyl Nuclear Power Plant in the Ukraine, which used to be a part of the Soviet Union.

It is considered to be the worst nuclear power plant disaster in history and the only level 7 instance on the International Nuclear Event Scale.

It is Decommissioned nuclear power station near the city of Pripyat.

It has Four reactors of type RBMK-1000, each capable of producing 1.000 MW

It is known because of an explosion of a reactor due to different design failures and human errors.

The accident started during a safety test on an RBMK-type nuclear reactor. The test was a simulation of an electrical power outage to help create a safety procedure for maintaining reactor cooling water circulation until the back-up electrical generators could provide power. Three such tests had been conducted since 1982, but they had failed to provide a solution.

The reason for this disaster was nuclear reaction which was used to produce nuclear energy which can be defined as:

The processes in which one or more nuclides are produced from the collisions between two atomic nuclei or one atomic nucleus and a subatomic particle. The nuclides produced from nuclear reactions are different from the reacting nuclei (commonly referred to as the parent nuclei).

Nuclear Fission

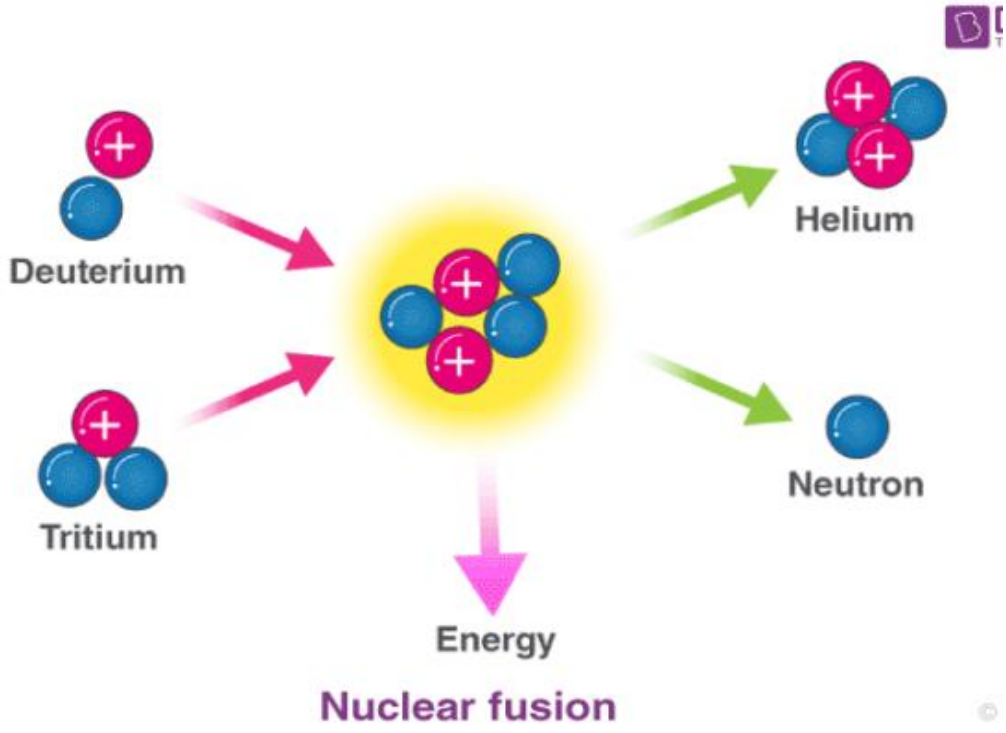
Nuclear fission refers to the splitting of an atomic nucleus into two or lighter nuclei. This process can occur through a nuclear reaction or through radioactive decay. Nuclear fission reactions often release a large amount of energy, which is accompanied by the emission of neutrons and gamma rays (photons holding huge amounts of energy, enough to knock electrons out of atoms).

- $^{235}U + {}^{1}n \longrightarrow {}^{141}Ba + {}^{92}Kr + 3\,{}^{1}n$
- $^{235}U + {}^{1}n \longrightarrow {}^{144}Xe + {}^{90}Sr + 2\,{}^{1}n$
- $^{235}U + {}^{1}n \longrightarrow {}^{146}La + {}^{87}Br + 3\,{}^{1}n$
- $^{235}U + {}^{1}n \longrightarrow {}^{137}Te + {}^{97}Zr + 2\,{}^{1}n$
- $^{235}U + {}^{1}n \longrightarrow {}^{137}Cs + {}^{96}Rb + 3\,{}^{1}n$

Nuclear Fusion

In nuclear fusion reactions, at least two atomic nuclei combine/fuse into a single nucleus. Subatomic particles such as neutrons or protons are also formed as products in these nuclear reactions.

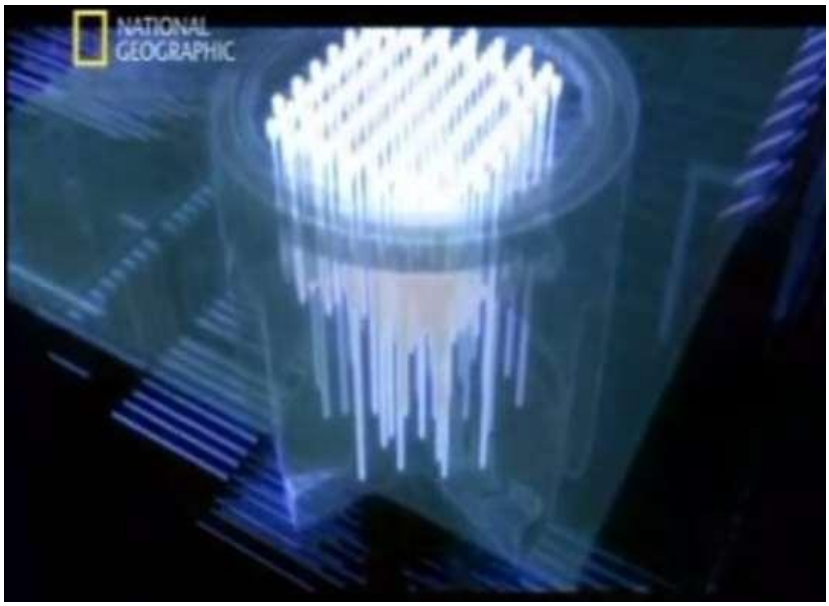
The nuclear fusion reaction between deuterium (2H) and tritium (3H) that yields helium (4He) and a neutron (1n) is provided above. Such fusion reactions occur at the core of the sun and other stars. The fusion of deuterium and tritium nuclei is accompanied by a loss of approximately 0.0188 amu of mass (which is completely converted into energy). Approximately 1.69*109 kilojoules of energy are generated for every mole of helium formed.



Chapter 2

RBMK-1000 Nuclear Plant

- Consists of different control rods that are responsible for regulating the heat with nuclear reactions
- To decrease the heat, more rods are inserted into the reactor
- The reactor produces more energy if it has more control rods down

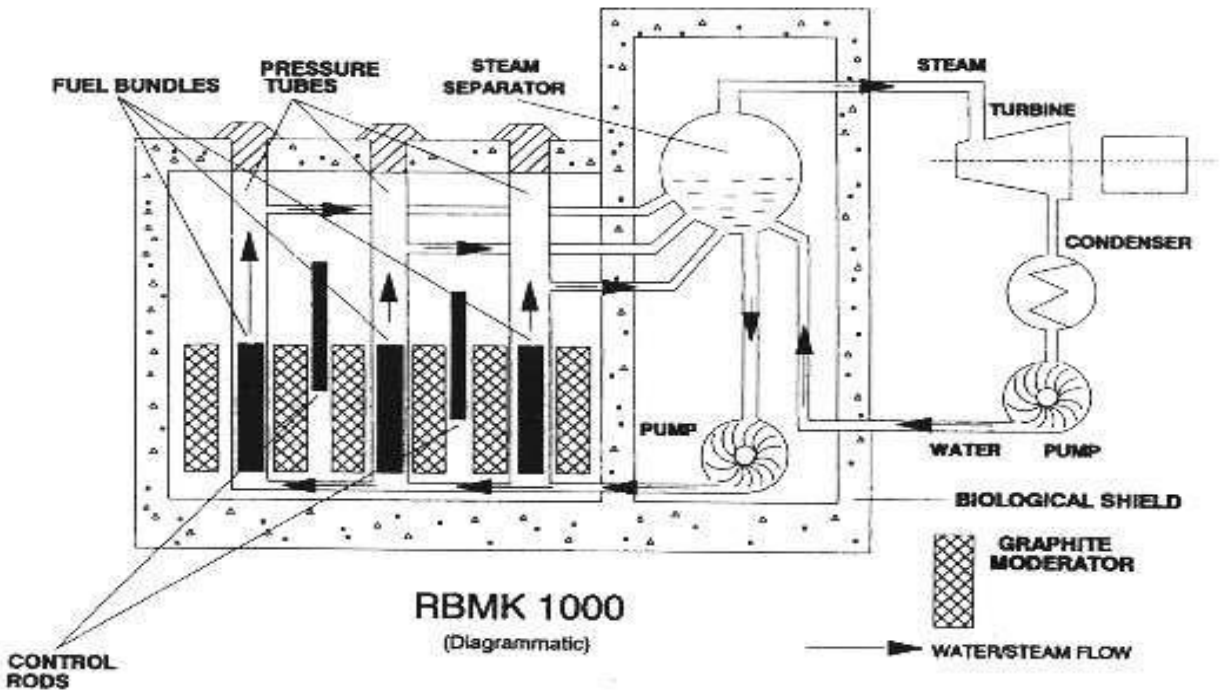


- The reactor has water on it, that transform into steam with the energy produced
- This foam steam boosts a turbine to generate electricity
- The water (in liquid state) also keeps the reactor on an appropriate temperature.

Chapter 3

Reactor Plant Scenario and What Happened?

1. As the reaction occurs, the uranium fuel becomes hot.
2. The water pumped through the core in pressure tubes removes the heat from the fuel.
3. The water is then boiled into steam.
4. The steam turns the turbines.
5. The water is then cooled.
6. Then the process repeats.



What Happened?

- The experiment involved shutting down the coolant pumps, which caused the coolant to rapidly heat up and boil.

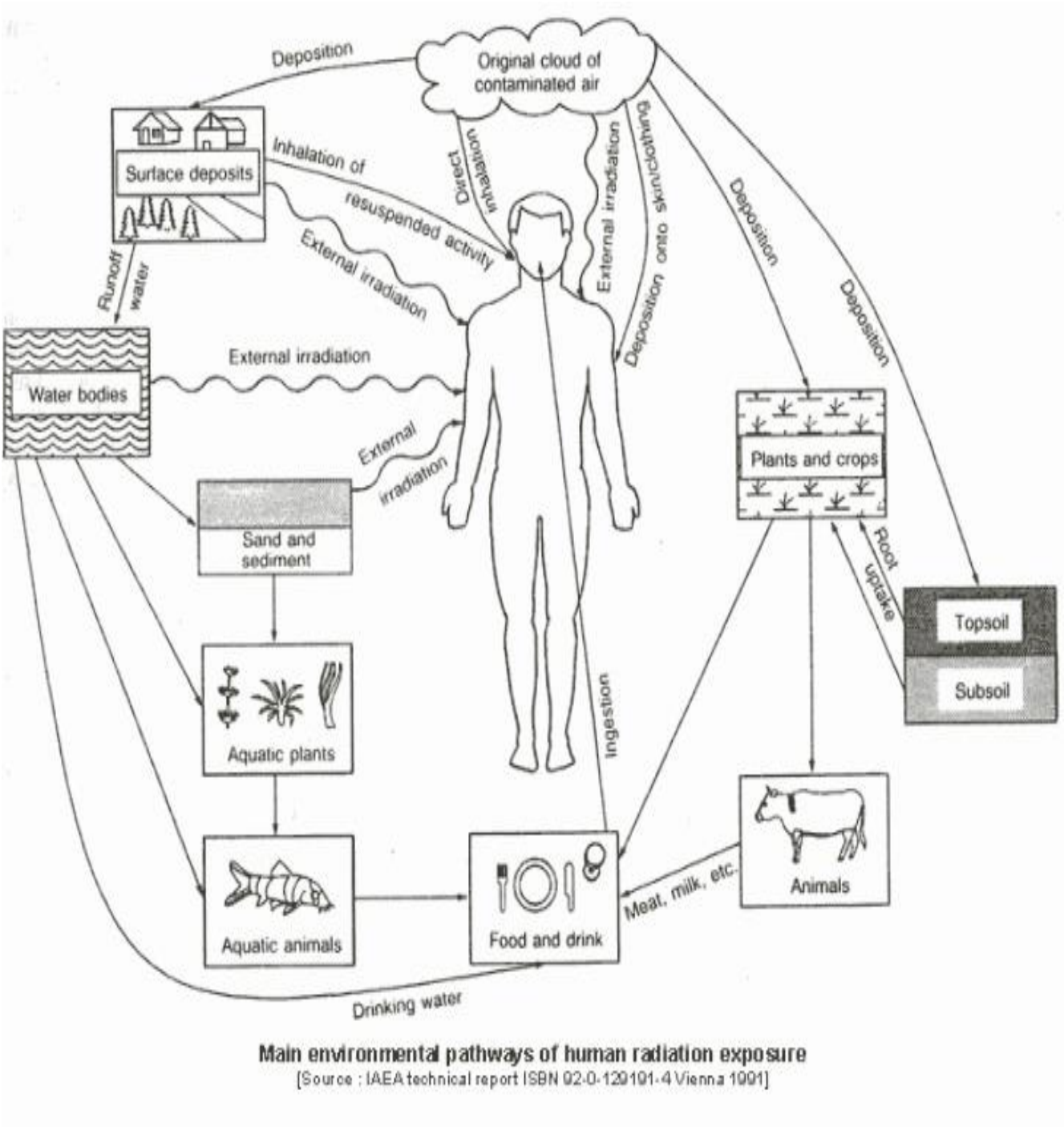
- Pockets of steam formed in the coolant lines. When the coolant expanded in this particular design, the power level went up.

- All control rods were ordered to be inserted. As the rods were inserted, they became deformed and stuck. The reaction could not be stopped.

- The rods melted and the steam pressure caused an explosion, which blew a hole in the roof. A graphite fire also resulted from the explosion.

Chapter 4

Cycle of Radioactive Metal



Main environmental pathways of human radiation exposure
[Source : IAEA technical report ISBN 92-0-129191-4 Vienna 1991]

Chapter 5

Effects and Impacts

Immediate Impacts

At the time of explosion 203 people were hospitalized immediately. 31 of them eventually died. Most of these people were workers in the plant or local firefighters.

NW winds from the Black Sea carried the radiation for miles in the following days. Scandinavian detectors picked up on the abundance of radiation, but the Soviet government denied everything.

- People were evacuated the day after the explosion.
- A month later 116,000 people in an 18-mile radius of the plant were evacuated.
- Over 300,000 people were moved from the accident.
- Many still live in contaminated areas and the long-term effect is not yet known.
- The Soviet Union has not been able to study effects due to lack of funds and secrecy.

Effects on the Environment

- Fallout levels were very high right around explosion and affected all wildlife.
- Red Forest- was a forest right by the plant was named this because plants had a red hue after the explosion.
- These trees also died from the amount of radiation they received.
- The Exclusion Zone around the Chernobyl nuclear power station is reportedly a haven for wildlife. As humans were evacuated from the area in 1986, existing animal populations multiplied and rare species not seen for centuries have returned or have been reintroduced, for example Eurasian lynx, wild boar, Eurasian wolf, Eurasian brown bear, European bison, Przewalski's horse, and Eurasian eagle owls.
- The majority of premature deaths caused by Chernobyl are expected to be the result of cancers and other diseases induced by radiation in the decades after the event.

Effects of Radiation

- The thyroid gland is the most vulnerable organ to radiation in the human body.
- Thyroid cancer can take 10-30 years to show its effects.
- There has been a 2,400% increase in the rates of thyroid cancer in Belarus since 1986.
- 2008 UNSCEAR report concluded that 134 staff and emergency workers suffered acute radiation syndrome and of those 28 died of radiation exposure within three months. Many of the survivors suffered skin conditions and radiation induced cataracts, and 19 had since died, but from conditions not necessarily associated with radiation exposure. Of the several hundred thousand liquidators, apart from some emerging indications of increased leukaemia, there was no other evidence of health effects.
- Greenpeace claimed contradictions in the Chernobyl Forum reports, quoting a 1998 WHO study referenced in the 2005 report, which projected 212 dead from 72,000 liquidators in its report, Greenpeace suggested there will be 270,000 cases of cancer attributable to Chernobyl fallout, and that 93,000 of these will probably be fatal.

Effects on Economy

The Chernobyl nuclear accident, and government policies adopted to cope with its consequences, imposed huge costs on the Soviet Union and three successor countries, Belarus, the Russian Federation and Ukraine. Although these three countries bore the brunt of the impact, given the spread of radiation outside the borders of the Soviet Union, other countries (in Scandinavia, for instance) sustained economic losses as well. Between 300,000 and 600,000 people were brought in to clean-up.

The costs of the Chernobyl nuclear accident can only be calculated with a high degree of estimation, given the non-market conditions prevailing at the time of the disaster and the high inflation and volatile exchange rates of the transition period that followed the break-up of the Soviet Union in 1991. However, the magnitude of the impact is clear from a variety of government estimates from the 1990s, which put the cost of the accident, over two decades, at hundreds of billions of dollars.

The Chernobyl accident and the measures taken to deal with its consequences have cost the Soviet Union – and later Belarus, the Russian Federation and Ukraine – hundreds of billions of dollars, but economic losses were also incurred by other countries.

Costs include:

- Direct damage caused by the accident.

- Expenditures related for instance to sealing off the reactor, treating the Exclusion Zone and other affected areas, resettling people, providing health care and social protection for those affected, monitoring radiation, and disposing of radioactive waste.

- Indirect costs linked to restrictions in the use of agricultural land and forests, and to the closure of industrial and agricultural facilities.

- Increased energy costs resulting from the closure of the Chernobyl plant and the cancellation of Belarus's nuclear power programme.

Chapter 6

Causes and Committed Error

There were 2 users in different rooms, responsible of the reactor number 4.

The user on the reactor climbed up several control rods to recover the power.

The user that controls the water introduce more water than necessary (steam can't be produced)

- To achieve a balance of steam and water, more rods than allowed are climbed up.
- The responsible of the water realize his error, and remove the excess of water.
- Power excess and water absence resulted on an excess of heat that melt the reactor core and resulted on an explosion.

- The events preceding the explosion allow highlight three types of errors
    - **Human:** Lack of communication and making erroneous decisions
    - **Design:** Unstable reactors and separation of responsible users

- **Automation:** The system allows actions that endanger security of the central

Noting these errors and the critical effects of the explosion, the question of whether the disaster could have been avoided and with which ways arises

Chapter 7

Proposed Solution

- Based on the committed errors, and looking to other nuclear plants, we proposed have different solutions for each type of error
    - **Human error**: it's necessary give them sufficient instruction, as well as a communication device to know every acted
    - **Design error**: Close the reactors of this type, and the new designs must have the controllers in the same room
    - **Automation error**: System can't afford to take dangerous actions

Proposed Solution I – Mobile Communication

- The users have to receive an adequate instruction
- Every action taken must be registered
- When it is registered, it is communicated to the other controllers
- The notification is made via mobile
- The user must read and confirm the messages before take this own decision.

Proposed Solution II – New Reactors and Rooms

- The RBMK reactors has problems in their design that makes them dangerous.
- Currently, there are 6 operative reactors of this type trying to get closed.
- The design of the most important parts has to be near and connected to favour the communication.

Proposed Solution III – Ban dangerous actions

- The system has to be enough automated to ban actions that are dangerous
- Those actions must be previously specified
- The user is notified about it

Chapter 8

Conclusion

- Chernobyl is a decommissioned nuclear power station where occurred one of the largest nuclear disasters in history
- The explosion was caused mainly due to three types of errors: humans, design and automation
- It could be avoided just with a good communication between users, despite of the bad design of the reactor and the nuclear plant.

From this project we would like to conclude that we have actually learnt a great deal about nuclear reactors and types of environmental effects that happens due to nuclear accidents and wastes. How gravely the environment is effected just because of a simple mistake. This innovative part that was added to our curriculum could prove to be very useful in future as we are trying to learn new things on our own and self-taught things are proven to be more effective as well as more useful for a person.

Chapter 9

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