WEBVTT

1 00:00:00.000 --> 00:00:01.560

2 00:00:01.560 --> 00:00:02.959 Yale podcast network.

3 00:00:05.000 --> 00:00:10.419 Hello and welcome to another episode of the Yale Journal of biology and medicine podcast.

4 00:00:10.419 --> 00:00:12.220 YJBM is a pub?

5 00:00:12.220 --> 00:00:20.879 Med indexed quarterly Journal edited by Yale medical graduate and professional students and peer reviewed by experts in the fields of biology and Medicine.

6 00:00:20.879 --> 00:00:29.190 Each issue of the Journal is devoted to a focus topic and through the YJBM podcast we will take you through the past,

7 00:00:29.190 --> 00:00:32.478 present and future of the issues subject matter.

8 00:00:32.552 --> 00:00:36.509 Recently, YJBM worked with the Yale Science diplomats,

9 00:00:36.509 --> 00:00:41.619 a scientific outreach group to host an event centered around our recent death issue,

10 00:00:41.619 --> 00:00:44.179 which was published in December of 2019.

11 00:00:44.179 --> 00:00:46.000 This event, science at brewery,

12 00:00:46.000 --> 00:00:47.829 featured a series of short,

13 00:00:47.829 --> 00:00:51.109 easily understandable talks about a topic of broad interest.

14 00:00:51.109 --> 00:00:58.409 In this case Death. We are releasing a modified version of these talks here in this edition of our podcast.

15 00:00:58.409 --> 00:01:04.700 My name is Emma Carly and I'm a second year graduate student in the Cell Biology Department.

16 00:01:04.700 --> 00:01:07.980 And will be our first speaker for today's podcast.

17 00:01:07.980 --> 00:01:13.799 Our second speaker is Elizabeth Nand, a second year student in the Microbial Pathogenesis Department.

18 00:01:13.799 --> 00:01:24.719 Our third speaker is Mike Bond a 4th year student in the pharmacology Department and our fourth speaker is Amanda Leiss a 6th year student in the Anthropology

19 00:01:24.719 --> 00:01:28.200 Department. So like I said before,

20 00:01:28.200 --> 00:01:33.329 my name is Emma and I will be talking to you all today about cell death,

21 00:01:33.329 --> 00:01:37.890 and specifically how cell death is a really important part of life.

22 00:01:37.890 --> 00:01:41.299 So cells are the basic building blocks of life.

23 00:01:41.299 --> 00:01:45.090 Everything is all living. Things are made up of cells.

24 00:01:45.090 --> 00:01:47.739 There are some organisms that are unicellular,

25 00:01:47.739 --> 00:01:51.530 meaning that they are made up of only one cell.

26 00:01:51.530 --> 00:02:02.900 An example of a unicellular Organism is Saccharomyces cerevisiae and the everyday term for this Organism is budding yeast and budding yeast are the type of yeast that

27 00:02:02.900 --> 00:02:06.579 are used to brew beer.

28 00:02:06.579 --> 00:02:16.840 Some organisms are multicellular. We humans are an example of multi cellular organisms and this means that we have lots of different types of cells that all work together to

29 00:02:16.840 --> 00:02:18.550 create one full functioning Organism.

30 00:02:18.550 --> 00:02:20.259 So we have brain cells,

31 00:02:20.259 --> 00:02:24.020 muscle cells, stomach cells, blood cells just to name a few,

32 00:02:24.020 --> 00:02:28.530 and all of these cells work together to make you.

33 00:02:28.530 --> 00:02:39.930 So let's so you know we're talking about cell death today and if our uni cellular Organism friends were to say have their one celled I that would be it.

34 00:02:39.930 --> 00:02:51.330 That would be the end of the Organism but for multi cellular organisms cell death is not as big of an issue in some cases because we have a lot

35 00:02:51.330 --> 00:02:59.759 of cells working together and in fact cell death is a very important part of life as a multi cellular Organism.

36 00:02:59.759 --> 00:03:02.849 So cells are constantly dying in multi cellular organisms.

37 00:03:02.849 --> 00:03:09.360 A day-to-day example of this is that our skin which is made up of lots and lots of cells,

38 00:03:09.360 --> 00:03:19.650 is constantly shedding so those are cells that have died and are flaking off the top and this is really important to maintain the integrity of your skin and to

39 00:03:19.650 --> 00:03:27.539 maintain its health and so if you were to cut a slice out of your skin and look at it sort of sideways,

40 00:03:27.539 --> 00:03:30.419 you would see that the bottom layer of.

41 00:03:30.419 --> 00:03:37.939 Your skin is made up of young new cells and as the cells move up towards the top layer of your skin,

42 00:03:37.939 --> 00:03:48.199 they get older and older and eventually die and so our skin is turning over or you get sort of fresh cells at the top every 10 to 30 days,

43 00:03:48.199 --> 00:03:54.020 which is pretty cool. Lots of other cells in our body are also turning over like this.

44 00:03:54.020 --> 00:03:59.490 Every four months we have fresh red blood cells that carry oxygen to our entire body.

45 00:03:59.490 --> 00:04:01.639 The cells that line our stomach.

46 00:04:01.639 --> 00:04:07.020 Are in a really harsh environment and so they turn over every two to nine days.

47 00:04:07.020 --> 00:04:10.710 But there are some cells that we have for a lifetime.

48 00:04:10.710 --> 00:04:20.790 An example of this are neurons and so the neurons that you have when you're born are the neurons that you will have forever and This is why diseases such

49 00:04:20.790 --> 00:04:29.360 as neurodegenerative disorders which lead to the death of these neurons are really debilitating because we can't replace those neurons once they're gone.

50 00:04:29.360 --> 00:04:37.569 And So what I'd like to talk to you about today is that cell death is actually a really critical part of life in multi cellular organisms.

51 00:04:37.569 --> 00:04:41.519 Cell death is important at the beginning during the development of these organisms,

52 00:04:41.519 --> 00:04:44.860 and it's important all the way throughout life to prevent disease.

53 00:04:44.860 --> 00:04:53.980 So to start of- I'm going to 1st talk about how cells die and so you know a cell is basically a bag of stuff and so an intuitive way

54 00:04:53.980 --> 00:04:59.490 to think about how a cell might die is that this bag just opens an explodes and.

55 00:04:59.490 --> 00:05:01.480 You know you're left with nothing.

56 00:05:01.480 --> 00:05:03.470 You're left with a dead cell,

57 00:05:03.470 --> 00:05:07.129 and this is one of the ways in which cells die.

58 00:05:07.129 --> 00:05:09.449 The scientific term for this is necrosis,

59 00:05:09.449 --> 00:05:17.089 and what happens during the crisis is that you have a healthy cell that has been exposed to some sort of a stress,

60 00:05:17.089 --> 00:05:19.410 such as a poison or high temperatures,

61 00:05:19.410 --> 00:05:22.399 or lack of oxygen, just to name a few,

62 00:05:22.399 --> 00:05:28.370 and as a result the cell will swell and all cells are encased by something called the membrane.

63 00:05:28.370 --> 00:05:30.699 And when the cells swell big enough,

64 00:05:30.699 --> 00:05:33.230 the memory will pop like a balloon.

65 00:05:33.230 --> 00:05:36.170 And the cell contents will spill out everywhere.

66 00:05:36.170 --> 00:05:38.750 And this actually isn't a good thing,

67 00:05:38.750 --> 00:05:45.009 because some of those cellular contents will then go and damage other surrounding parts of that issue.

68 00:05:45.009 --> 00:05:48.319 And this can lead to inflammation and tissue damage.

69 00:05:48.319 --> 00:05:53.470 So while this exploding over this necrosis is something that happens in our body,

70 00:05:53.470 --> 00:05:56.779 it's not the best way for ourselves to die,

71 00:05:56.779 --> 00:06:04.610 and so our body has come up with a different type of cell death that will prevent this sort of catastrophic.

72 00:06:04.610 --> 00:06:15.949 Damage to the Organism and this type of cell death is called a pop ptosis or programmed cell death and so a pop ptosis is sort of this intentional targeted

73 00:06:15.949 --> 00:06:23.129 killing of cells and 50 to 70 billion of our cells die every day due to a pop ptosis.

74 00:06:23.129 --> 00:06:30.310 But don't worry you are made up of 32.7 trillion cells and so this means that only about .2%

75 00:06:30.310 --> 00:06:35.120 of your cells die every day due to a pop ptosis.

76 00:06:35.120 --> 00:06:45.740 So during a pop ptosis you have a healthy cell and for some reason the body wants to get rid of it and so a pop ptosis is initiated and

77 00:06:45.740 --> 00:06:56.360 during a pop ptosis cells will shrink and they will start to blab which is a scientific term for which basically means that the self starts to break off into

78 00:06:56.360 --> 00:06:58.129 little packets in little pieces.

79 00:06:58.129 --> 00:07:06.870 And the important thing here is that that membrane that encloses ourselves never breaks all the cell contents stay contained in these little packets.

80 00:07:06.870 --> 00:07:11.459 And eventually they are eaten up by other cells through a process called phagocytosis.

81 00:07:11.459 --> 00:07:21.300 So basically there are other cells will come along sort of like PAC man and chew up these little balls and digest them so that you can use the components

82 00:07:21.300 --> 00:07:23.269 of the cells for other things.

83 00:07:23.269 --> 00:07:26.879 So since the cell membrane never breaks during a pop ptosis,

84 00:07:26.879 --> 00:07:36.709 you don't get the devastating information that you get with necrosis and so our body likes to have cells die via a pop ptosis instead of necrosis.

85 00:07:36.709 --> 00:07:41.170 So now that we have a better idea about how cells die.

86 00:07:41.170 --> 00:07:45.269 I'd like to talk about why this cell death is important.

87 00:07:45.269 --> 00:07:56.211 So a pop ptosis was actually first described in the context of development and a pop ptosis is really important during the development of multicellular organisms a pop ptosis was

88 00:07:56.266 --> 00:07:59.769 first described specifically during the development of C elegans,

89 00:07:59.769 --> 00:08:06.870 which is a type of nematode worm that scientists use a lot to understand various basic biology questions.

90 00:08:06.870 --> 00:08:08.790 Um, and so because C.

91 00:08:08.790 --> 00:08:11.089 Elegans is a very simple animal.

92 00:08:11.089 --> 00:08:13.399 We know a lot about it.

93 00:08:13.399 --> 00:08:17.240 In fact, we know the exact way that these C.

94 00:08:17.240 --> 00:08:26.449 Elegans go from an embryo to a full worm an we know the fate of every single cell that is made during this process.

95 00:08:26.449 --> 00:08:31.829 So we know that exactly 1090 cells are created during the development of C.

96 00:08:31.829 --> 00:08:36.940 Elegans, and more importantly, we know that exactly 130 one of these cells.

97 00:08:36.940 --> 00:08:49.720 Undergo a pop ptosis so a scientist can watch a worm developing and say Oh I know exactly which of these cells are going to die because the exact same

98 00:08:49.720 --> 00:09:02.500 131 cells die every single time and so by noticing that the cells die exactly the same every single time via Apoptose as scientists realize that a pop ptosis is

99 00:09:02.500 --> 00:09:07.730 an intentional process. It's highly regulated and sells so a pop ptosis.

100 00:09:07.730 --> 00:09:09.940 Is also very important in human development,

101 00:09:09.940 --> 00:09:18.759 and a great example of this is in development of our limbs are arms in our legs and so if you look at your hands and your feet,

102 00:09:18.759 --> 00:09:23.480 most of us have individual fingers and toes and Orlins didn't start out that way.

103 00:09:23.480 --> 00:09:27.259 When we were embryos, orlins actually started off as a limb Bud,

104 00:09:27.259 --> 00:09:36.080 which is sort of just this round ball that slowly grows out from where your shoulders and your hips eventually are to create your arms in your legs.

105 00:09:36.080 --> 00:09:42.669 And so once this limb buds sort of starts to reach what will become your hands and your feet.

106 00:09:42.669 --> 00:09:44.710 Cells begin to selectively start dying,

107 00:09:44.710 --> 00:09:47.769 sort of, in between what will become your fingers,

108 00:09:47.769 --> 00:09:50.490 and so this cell death is a pop.

109 00:09:50.490 --> 00:10:00.129 Ptosis and our body is able to very tightly control which cells are going to be dying this way so that we can properly make all of our.

110 00:10:00.129 --> 00:10:01.700 Fingers and all of our toes.

111 00:10:01.700 --> 00:10:04.570 And so if you look at your fingers and your toes,

112 00:10:04.570 --> 00:10:07.179 you can see that there's some webbing in between them,

113 00:10:07.179 --> 00:10:12.139 and this is. These are the cells you know that we're sort of at the edge of what were,

114 00:10:12.139 --> 00:10:13.700 and we're not going to die.

115 00:10:13.700 --> 00:10:16.830 And so some people have more webbing between their fingers than others,

116 00:10:16.830 --> 00:10:22.169 which means that not as many of their cells underwent a pop ptosis during development.

117 00:10:22.169 --> 00:10:27.059 So not only is cell death really important for development of multicellular organisms,

118 00:10:27.059 --> 00:10:31.950 but it's also really important to maintain their health and to prevent disease.

119 00:10:31.950 --> 00:10:35.710 So a pop ptosis can prevent lots of different diseases.

120 00:10:35.710 --> 00:10:43.980 Today I'm specifically going to talk about the role of a pop ptosis and preventing cancer and in preventing infection by viruses.

121 00:10:43.980 --> 00:10:46.230 So first I'll talk about cancer.

122 00:10:46.230 --> 00:10:48.110 Cancer is uncontrolled cell growth.

123 00:10:48.110 --> 00:10:54.820 Basically something happened to these cells and they grow out of control and they form a tumor.

124 00:10:54.820 --> 00:10:57.600 And this can cause very devastating effects.

125 00:10:57.600 --> 00:11:01.570 The surrounding tissues, and ultimately the person gets very ill.

126 00:11:01.570 --> 00:11:08.320 The trigger for cancer is mutations that arise in DNA and so just to break that down.

127 00:11:08.320 --> 00:11:20.230 DNA is the genetic code that gives all the information that your cells need to make you to make an Organism so it has all the information to make a

128 00:11:20.230 --> 00:11:25.070 full person. This information can be mutated or changed due to various.

129 00:11:25.070 --> 00:11:28.620 Outside things, an example. This is in skin cancer,

130 00:11:28.620 --> 00:11:38.070 UV radiation from the sun can damage the DNA in your skin and cause some sort of a mutation that could lead to cancer.

131 00:11:38.070 --> 00:11:42.009 So there are different types of mutations that can occur.

132 00:11:42.009 --> 00:11:48.710 You can get breaks in the DNA where it literally gets cut in half and chopped up,

133 00:11:48.710 --> 00:11:51.860 or you can have changes in this information.

134 00:11:51.860 --> 00:11:55.080 So another type of Mutation is that the.

135 00:11:55.080 --> 00:12:00.539 Actual information encoded in your DNA can be changed and as you can imagine,

136 00:12:00.539 --> 00:12:10.980 this would lead to very potentially lead to catastrophic issues in the cells and so these mutations are basically what leads to uncontrolled cell growth.

137 00:12:10.980 --> 00:12:18.080 So our body has ways of dealing with this to make sure that sells that are mutated don't necessarily become cancer,

138 00:12:18.080 --> 00:12:23.179 and so a pop ptosis is really important to remove six cells.

139 00:12:23.179 --> 00:12:34.080 Inside of our bodies, inside of ourselves there's this sort of DNA house called the nucleus that protects all of our DNA from potential damages inside of the nucleus.

140 00:12:34.080 --> 00:12:41.230 There are lots of different factors that are constantly surveilling the DNA to see if it's damaged or not,

141 00:12:41.230 --> 00:12:46.029 and one of these factors is called P53 and P53 is actually really,

142 00:12:46.085 --> 00:12:48.000 really important in cancer biology.

143 00:12:48.000 --> 00:12:50.629 It's called the Guardian of the genome.

144 00:12:50.629 --> 00:12:54.509 It protects US from cancer and a lot of cancers.

145 00:12:54.509 --> 00:12:56.720 Are usually somehow associated with P.

146 00:12:56.720 --> 00:12:58.929 53 so in healthy cells P.

147 00:12:58.929 --> 00:13:02.240 53 is looking around the DNA looking for damage,

148 00:13:02.240 --> 00:13:04.080 and if it spots damage,

149 00:13:04.080 --> 00:13:06.649 it tells the cell hey stop growing.

150 00:13:06.649 --> 00:13:08.490 Can we fix this damage?

151 00:13:08.490 --> 00:13:19.169 And if the cell says no then P53 says OK we need to initiate a pop ptosis and kill this cell to make sure that it doesn't become cancerous,

152 00:13:19.169 --> 00:13:23.950 but cancer cells are able to cheat death by messing with P 53.

153 00:13:23.950 --> 00:13:25.899 So sometimes cancer cells have.

154 00:13:25.899 --> 00:13:28.080 P 53 that's a little messed up.

155 00:13:28.080 --> 00:13:29.940 It's the wrong shape, for example,

156 00:13:29.940 --> 00:13:32.120 and so it can't read DNA anymore.

157 00:13:32.120 --> 00:13:33.679 It can't do its job.

158 00:13:33.679 --> 00:13:37.100 Can't find those brakes. And so when the cell says hey,

159 00:13:37.100 --> 00:13:38.649 P 53 is everything OK,

160 00:13:38.649 --> 00:13:40.830 P 53 is like I don't know,

161 00:13:40.830 --> 00:13:45.799 I can't really tell if anything's up because the cancer has sort of made it wonky.

162 00:13:45.799 --> 00:13:49.539 There are other types of cancers where P 53 is just gone,

163 00:13:49.539 --> 00:13:53.580 and so when the cell checks in and says hey is everything OK?

164 00:13:53.580 --> 00:13:55.129 It doesn't get a reply,

165 00:13:55.129 --> 00:14:00.299 and so sort of. In response to this wonky or missing P 53 sounds like OK,

166 00:14:00.299 --> 00:14:05.779 I guess everything's fine and it just keeps growing and that is what ultimately leads to cancer.

167 00:14:05.779 --> 00:14:16.440 So these sort of surveilling factors are really important to identify cells that need to undergo a pop ptosis so that they don't become cancer in the future.

168 00:14:16.440 --> 00:14:22.409 OK so a pop ptosis is also important to prevent illnesses that arise due to other factors.

169 00:14:22.409 --> 00:14:26.269 For example viruses. So a brief intro to how viruses work.

170 00:14:26.269 --> 00:14:31.529 Basically viruses will come into your body an infect your cells and make them sick.

171 00:14:31.529 --> 00:14:42.059 And what this means is that the virus will basically hijack the cell and turn it into a virus factory that will spew out more viruses that can go and

172 00:14:42.059 --> 00:14:46.639 in fact more cells in your body and ultimately this is what.

173 00:14:46.639 --> 00:14:48.580 Is going to make you ill.

174 00:14:48.580 --> 00:14:54.149 Our body halves various mechanisms to get rid of cells that have been infected by viruses,

175 00:14:54.149 --> 00:14:57.629 and one of these mechanisms is another type of cell.

176 00:14:57.629 --> 00:15:01.460 That sort of a defense sell their called natural killer cells.

177 00:15:01.460 --> 00:15:04.940 Natural killer cells are a type of white blood cells,

178 00:15:04.940 --> 00:15:14.330 so their circulating in your blood and white blood cell on this natural killer cell will look for various cells that might be under attacked by viruses.

179 00:15:14.330 --> 00:15:17.120 How does it know what to look for?

180 00:15:17.120 --> 00:15:20.789 Well, cells have these signals on the outside that say.

181 00:15:20.789 --> 00:15:24.629 I'm healthy, everything's fine. You know you don't need to kill me,

182 00:15:24.629 --> 00:15:26.230 I'm not a virus factory,

183 00:15:26.230 --> 00:15:29.110 but when a cell becomes infected by a virus,

184 00:15:29.110 --> 00:15:34.870 the signals on the outside of the cell chained and it says hey there is something wrong here.

185 00:15:34.870 --> 00:15:36.470 I'm infected by a virus.

186 00:15:36.470 --> 00:15:46.070 You need to kill me and so the natural killer cell can recognize this signal on these virally infected cells and will induce a pop ptosis in those cells to

187 00:15:46.070 --> 00:15:48.860 prevent the spread of the virus.

188 00:15:48.860 --> 00:15:57.659 So overall, I hope that you've learned that cells can dive Rea multiple mechanisms that can Divya necrosis or a pop ptosis.

189 00:15:57.659 --> 00:16:09.659 But the a pop ptosis is really the mechanism by which cells can die in a very intentional way that does not cause further damage to the body and a

190 00:16:09.659 --> 00:16:18.059 pop ptosis is really critical for development of multicellular organisms and to maintain the health of these organisms by preventing diseases.

191 00:16:19.710 --> 00:16:20.000 Hi,

192 00:16:20.000 --> 00:16:25.700 I'm Elizabeth NAND and as Emma mentioned I am a second year graduate student in the Department of microbial pathogenesis.

193 00:16:25.700 --> 00:16:31.809 Today I'm going to be talking to you about a deadly poison or really two of them.

194 00:16:31.809 --> 00:16:35.669 So before I begin, I want to pose to you a question.

195 00:16:35.669 --> 00:16:37.279 What do water, anti-freeze, Botox,

196 00:16:37.279 --> 00:16:38.889 and uranium have in common?

197 00:16:38.889 --> 00:16:41.149 So think about that for a second.

198 00:16:41.149 --> 00:16:42.759 May seem a little weird,

199 00:16:42.759 --> 00:16:45.980 but in fact all four of these things are poisons.

200 00:16:45.980 --> 00:16:48.879 Now you might be saying water is a poison.

201 00:16:48.879 --> 00:16:53.710 Yes, yes it is, and will dive into how and why in a little bit.

202 00:16:53.710 --> 00:16:56.929 But first we have to define what is a poison.

203 00:16:56.929 --> 00:17:01.490 So poison is a substance that is capable of causing the illness or death.

204 00:17:01.490 --> 00:17:04.950 Of a living Organism. When introduced or absorbed.

205 00:17:04.950 --> 00:17:07.069 There are many kinds of poisons,

206 00:17:07.069 --> 00:17:10.250 but broadly they fall into the categories of natural,

207 00:17:10.250 --> 00:17:16.930 chemical, or radiological. But what's critically important about poison is that everything is poisonous,

208 00:17:16.930 --> 00:17:19.230 just the dose makes the poison.

209 00:17:19.230 --> 00:17:24.589 So paracelsus, who is the father of toxicology who lived from 1493 to 1541.

210 00:17:24.589 --> 00:17:26.890 He said that everything is poison.

211 00:17:26.890 --> 00:17:28.809 There is poison in everything.

212 00:17:28.809 --> 00:17:31.099 Only the dose makes a thing,

213 00:17:31.099 --> 00:17:35.700 not a poison, and that's super important for how we measure poisons.

214 00:17:35.700 --> 00:17:39.150 How we measure the how poisonous something actually is.

215 00:17:39.150 --> 00:17:43.109 So we use the measure called LD 50 to measure.

216 00:17:43.109 --> 00:17:45.849 Poison and LD50 stands for lethal dose,

217 00:17:45.849 --> 00:17:52.519 50%. That is, the amount of a substance per body weight in kilograms that will kill 50%

218 00:17:52.519 --> 00:17:54.869 of the test population. For reference,

219 00:17:54.869 --> 00:17:58.009 the average adult American male weighs 90 kilograms,

220 00:17:58.009 --> 00:18:03.200 while the average adult American female will weighs 77 kilograms.

221 00:18:03.200 --> 00:18:05.890 So LD 50 is calculated from a graph.

222 00:18:05.890 --> 00:18:10.589 So basically what happens is scientists will take a test population of usually mice.

223 00:18:10.589 --> 00:18:17.309 They will take their toxin of interest and then they will inject the mice with increasing doses of that toxin.

224 00:18:17.309 --> 00:18:18.990 So they'll start with zero,

225 00:18:18.990 --> 00:18:24.029 and then they'll go up to a dose at which all of the mice die.

226 00:18:24.029 --> 00:18:29.740 They then get a graph that looks like a curve they can calculate at what dose 50%

227 00:18:29.740 --> 00:18:34.950 of the population died, and then that will give them the LD 50.

228 00:18:34.950 --> 00:18:38.289 An example of an LD50 is for palytoxin,

229 00:18:38.289 --> 00:18:44.980 a marine chemical toxin, and the LD 50 for Pally toxin is 599.3 micrograms per kilogram.

230 00:18:44.980 --> 00:18:52.089 What that means is that 599.3 micrograms per kilogram of body weight is enough to kill 50%

231 00:18:52.089 --> 00:18:55.430 of the population. To put that into context,

232 00:18:55.430 --> 00:19:02.259 for humans, that means about 1/4 cup of palytoxin will kill an average adult human.

233 00:19:02.259 --> 00:19:06.380 So let's go back to that original question that I posed about water,

234 00:19:06.380 --> 00:19:07.970 antifreeze, Botox, and uranium. Well,

235 00:19:07.970 --> 00:19:11.769 how much of each of these things is enough to kill you?

236 00:19:11.769 --> 00:19:13.359 What are their LD 50s?

237 00:19:13.359 --> 00:19:16.839 Well, the LD 50 of water is 90 milliliters per kilogram.

238 00:19:16.839 --> 00:19:18.430 To put that into context,

239 00:19:18.430 --> 00:19:25.400 that means that you would need to drink 2 gallons of water all at once without pausing to die of water poisoning.

240 00:19:25.400 --> 00:19:27.299 And that seems a little silly,

241 00:19:27.299 --> 00:19:29.210 because it is a little silly,

242 00:19:29.210 --> 00:19:32.789 and that's why we don't usually consider water poisonous.

243 00:19:32.789 --> 00:19:36.240 However, the LD 50 for antifreeze is much more reasonable.

244 00:19:36.240 --> 00:19:39.000 The LD 50 is 1.4 milliliters per kilogram.

245 00:19:39.000 --> 00:19:44.180 And that means that you would only need to drink 1 1/2 cups of antifreeze.

246 00:19:44.180 --> 00:19:48.660 That means that a large glass of antifreeze is enough to kill you.

247 00:19:48.660 --> 00:19:50.390 Botox, on the other hand,

248 00:19:50.390 --> 00:19:53.490 has an LD 50 of one nanogram per kilogram,

249 00:19:53.490 --> 00:19:55.220 and if that sounds low,

250 00:19:55.220 --> 00:19:56.940 it's because it is very,

251 00:19:56.940 --> 00:20:00.180 very low. The LD 50 of uranium is 5.

252 00:20:00.180 --> 00:20:05.470 Grams per kilogram, which means that you would need to eat 1.5 cups of uranium to die.

253 00:20:05.470 --> 00:20:08.269 I don't know why you would ever do that,

254 00:20:08.269 --> 00:20:13.109 but there it is. So now you might be thinking,

255 00:20:13.109 --> 00:20:16.849 well, OK, that's great. But what should I know about poisons?

256 00:20:16.849 --> 00:20:20.609 And I think there are five things that you should know about poisons.

257 00:20:20.609 --> 00:20:22.920 The first being, How do I get it?

258 00:20:22.920 --> 00:20:25.230 The second being, what does it do then?

259 00:20:25.230 --> 00:20:26.680 How much will kill you?

260 00:20:26.680 --> 00:20:29.279 How long do you have if you get poisoned?

261 00:20:29.279 --> 00:20:30.720 And can you fix it?

262 00:20:30.720 --> 00:20:36.180 And we're going to go through these five questions for two different poisons.

263 00:20:36.180 --> 00:20:38.259 But before we go through that,

264 00:20:38.259 --> 00:20:40.339 we need to establish another definition,

265 00:20:40.339 --> 00:20:43.119 and this definition is that of a toxin.

266 00:20:43.119 --> 00:20:48.670 So you might have heard the word toxin before in the context of smoothies or tea.

267 00:20:48.670 --> 00:20:51.799 But the word toxin actually has a scientific definition.

268 00:20:51.799 --> 00:20:53.880 A toxin is an antigenic poison,

269 00:20:53.880 --> 00:20:56.309 or venom of plant or animal origin,

270 00:20:56.309 --> 00:21:03.250 especially one produced by or derived from micro organisms and causing disease when present at low concentration in the body.

271 00:21:03.250 --> 00:21:07.630 So what's really important here is that a toxin is produced by.

272 00:21:07.630 --> 00:21:11.769 Plant or animal and natural strictly means produced by nature,

273 00:21:11.769 --> 00:21:15.079 so there are actually two kinds of toxin,

274 00:21:15.079 --> 00:21:22.740 there're poisons and venoms. A poison is when an Organism produces a toxin that causes harm when eaten or absorbed.

275 00:21:22.740 --> 00:21:29.480 So think a poison dart frog of Venom is when an Organism produces a toxin that causes harm when injected.

276 00:21:29.480 --> 00:21:32.180 So think of snake like the black mamba.

277 00:21:32.180 --> 00:21:34.200 Now that we've established some definitions,

278 00:21:34.200 --> 00:21:36.900 we can move on to our first poison,

279 00:21:36.900 --> 00:21:38.920 and this one is botulinum toxin.

280 00:21:38.920 --> 00:21:42.630 So it's produced by the common soil bacterium called Clostridium Botulinum,

281 00:21:42.630 --> 00:21:45.660 and it is the most poisonous substance on Earth.

282 00:21:45.660 --> 00:21:47.920 Hands down. No one debates this.

283 00:21:47.920 --> 00:21:52.509 The LD 50 is one nanogram per kilogram.

284 00:21:52.509 --> 00:21:54.630 That to put that into context,

285 00:21:54.630 --> 00:21:57.470 that means that a crystal of botulinum toxin,

286 00:21:57.470 --> 00:22:02.420 the size of a grain of sand is enough to kill around 9600 people.

287 00:22:02.420 --> 00:22:04.900 So botulinum toxin causes the disease Botulism.

288 00:22:04.900 --> 00:22:07.019 But how do you get Botulism?

289 00:22:07.019 --> 00:22:10.920 Will most exposures to botulinum toxin come through improperly canned food?

290 00:22:10.920 --> 00:22:13.400 Babies can also get Botulism from honey,

291 00:22:13.400 --> 00:22:19.059 so now I don't want you to sit here being terrified of canned food and honey,

292 00:22:19.059 --> 00:22:22.680 because there are fewer than 1000 cases per year of.

293 00:22:22.680 --> 00:22:26.255 Botulism? When it does occur,

294 00:22:26.323 --> 00:22:30.819 it usually happens because the cans that the food was preserved in.

295 00:22:30.819 --> 00:22:40.460 We're not sterilized properly, and with honey only babies can get Botulism from honey because the spores or the dormant forms of the bacterium.

296 00:22:40.460 --> 00:22:42.769 They can survive in honey.

297 00:22:42.769 --> 00:22:48.349 But adult immune systems are developed enough to clear the Spores before they start producing botulinum toxin.

298 00:22:48.349 --> 00:22:49.990 Babies, on the other hand,

299 00:22:49.990 --> 00:22:53.609 have. You need systems that aren't quite as developed,

300 00:22:53.609 --> 00:22:57.720 which means that the spores can germinate and can give the babies Botulism,

301 00:22:57.720 --> 00:23:01.799 so you shouldn't feed honey to babies under 12 months.

302 00:23:01.799 --> 00:23:07.619 However, adults are fine. But what is Botulism actually do?

303 00:23:07.619 --> 00:23:10.779 Well, Botulism causes a limp paralysis?

304 00:23:10.779 --> 00:23:14.359 Symptoms usually begin between 18 and 36 hours after Ingestion.

305 00:23:14.359 --> 00:23:16.869 The cause of death is as fixation,

306 00:23:16.869 --> 00:23:19.009 and that means you can't breathe.

307 00:23:19.009 --> 00:23:22.240 So I set the Botulism causes a limb paralysis.

308 00:23:22.240 --> 00:23:24.029 But Why is that? Well,

309 00:23:24.029 --> 00:23:30.829 to put it briefly, your neurons work by transmitting messages in the form of neurotransmitters from cell to cell.

310 00:23:30.829 --> 00:23:34.049 Botulinum toxin prevents the cells from sending those messages,

311 00:23:34.049 --> 00:23:36.559 which means that your nerves can't fire.

312 00:23:36.559 --> 00:23:38.700 So so botulinum toxin comes in,

313 00:23:38.700 --> 00:23:42.549 and it prevents your nerves from talking to each other.

314 00:23:42.549 --> 00:23:44.369 This causes the limp paralysis,

315 00:23:44.369 --> 00:23:54.559 so the good news is that there is an anti toxin for Botulism and supportive care along with the anti toxin are very effective in treating the disease.

316 00:23:54.559 --> 00:24:02.930 So what the anti toxin does is it binds to the free botulinum toxin and it prevents it from doing any further damage.

317 00:24:02.930 --> 00:24:13.640 Unfortunately the antitoxin does not reverse damage that's already been done so if you are unfortunate enough to contract Botulism you will need supportive care until your symptoms subside.

318 00:24:13.640 --> 00:24:15.170 But the good news is,

319 00:24:15.170 --> 00:24:19.450 is that with modern care the death rate of Botulism has dropped from 50%

320 00:24:19.450 --> 00:24:23.029 to only 5%. So before I move on,

321 00:24:23.029 --> 00:24:25.200 I want to tell you a really,

322 00:24:25.200 --> 00:24:28.619 really cool story that I found while I was researching this,

323 00:24:28.619 --> 00:24:32.039 and that is about a horse and you might be thinking,

324 00:24:32.039 --> 00:24:35.150 why does a horse have anything to do with Botulism?

325 00:24:35.150 --> 00:24:42.619 So in the late 1960s there was a horse and its name was first flight and this horse was supposed to be a resource.

326 00:24:42.619 --> 00:24:46.039 But this horse was way too skittish to be a racehorse,

327 00:24:46.039 --> 00:24:50.079 so its owner donated it to the US Army and then the usr.

328 00:24:50.079 --> 00:24:54.430 We said, OK, well. What are we going to do with this horse?

329 00:24:54.430 --> 00:24:56.079 So then they said, well,

330 00:24:56.079 --> 00:24:59.380 what if we use this horse to make botulinum antitoxin?

331 00:24:59.380 --> 00:25:01.029 So that's what they did.

332 00:25:01.029 --> 00:25:04.990 So what that means is they injected the horse with very very,

333 00:25:04.990 --> 00:25:06.970 very low levels of botulinum toxin,

334 00:25:06.970 --> 00:25:08.950 not enough to kill the horse,

335 00:25:08.950 --> 00:25:13.240 but enough so that the horse had an immune response to the toxin.

336 00:25:13.240 --> 00:25:17.859 They could then take the immune molecules from the horse and then purify them,

337 00:25:17.859 --> 00:25:22.480 and that is what botulinum anti toxin is.

338 00:25:22.480 --> 00:25:33.009 So a fun fact is that most of the botulinum anti toxin produced between 1970 and 1990 came from this one horse in the US Army.

339 00:25:33.009 --> 00:25:36.250 So if you are unfortunate to contract Botulism,

340 00:25:36.250 --> 00:25:40.589 you can think about the horse first flight and.

341 00:25:40.589 --> 00:25:48.130 How it skidded the held the skittish horse is the reason why you are now probably going to be fine in about a month.

342 00:25:48.130 --> 00:25:52.210 So now I'm going to switch gears and talk about some poisonous plants.

343 00:25:52.210 --> 00:25:54.089 And when I say poisonous plants,

344 00:25:54.089 --> 00:25:56.289 you might think of Nightshade or foxglove,

345 00:25:56.289 --> 00:26:03.200 but the other thing that you might think of as Poison Ivy and I am here to tell you that Poison Ivy,

346 00:26:03.200 --> 00:26:05.710 poison Oak, and poison sumac are not poisonous,

347 00:26:05.710 --> 00:26:08.220 and you might be sitting here thinking going.

348 00:26:08.220 --> 00:26:10.109 What the heck? Yes, they are,

349 00:26:10.109 --> 00:26:14.259 I know. Because I have gotten horrible rashes from these things,

350 00:26:14.259 --> 00:26:18.849 but what's interesting is those rashes are not actually technically a poison.

351 00:26:18.849 --> 00:26:20.769 They are an allergic reaction,

352 00:26:20.769 --> 00:26:27.660 so Poison Ivy produces a compound called Arushi all but on its own or rushel is completely harmless.

353 00:26:27.660 --> 00:26:31.109 It doesn't actually do any damage to your cells.

354 00:26:31.109 --> 00:26:34.940 However, Arushi all triggers an allergic reaction in most humans,

355 00:26:34.940 --> 00:26:38.390 and this allergic reaction is called allergic contact dermatitis.

356 00:26:38.390 --> 00:26:41.980 And that is what actually causes the rash.

357 00:26:41.980 --> 00:26:47.930 Interestingly, there are some lucky people who are not allergic to Poison Ivy and do not get a rash.

358 00:26:47.930 --> 00:26:52.940 Unfortunately, most of us are and I hope that you have never had to experience it.

359 00:26:52.940 --> 00:26:57.630 However, if you do, you can have a fun fact to tell your friends that,

360 00:26:57.630 --> 00:26:59.509 well, this isn't actually a poison.

361 00:26:59.509 --> 00:27:03.890 It's actually an allergy. I don't know if that will help you very much,

362 00:27:03.890 --> 00:27:09.519 but at least you can feel a little bit better for knowing something if Poison Ivy isn't poisonous,

363 00:27:09.519 --> 00:27:12.109 you might be asking then what on Earth?

364 00:27:12.109 --> 00:27:13.930 Is well, lots of things.

365 00:27:13.930 --> 00:27:15.740 Everything from pointsettia to Oleander,

366 00:27:15.740 --> 00:27:19.369 from elderberry to daffodils. All of these things are poisonous,

367 00:27:19.369 --> 00:27:23.359 but today I'm going to focus on one of these things,

368 00:27:23.359 --> 00:27:25.539 and that is the Castor plant.

369 00:27:25.539 --> 00:27:28.809 So the Castor plant produces a protein called Rice,

370 00:27:28.809 --> 00:27:32.799 and you might have heard of rice in from spy novels,

371 00:27:32.799 --> 00:27:38.609 or from that time that the US government accidentally shipped racing around the country in envelopes.

372 00:27:38.609 --> 00:27:43.779 But that aside, the Castor plant is widely grown for making Castor oil.

373 00:27:43.779 --> 00:27:45.869 So if you use Castor oil,

374 00:27:45.869 --> 00:27:56.339 don't worry. Castor oil is processed in such a way that it does not contain any rice and however the mash or the leftover plant product after making Castor oil

375 00:27:56.339 --> 00:27:59.829 does contain rice and so now you might be thinking,

376 00:27:59.829 --> 00:28:02.630 well, OK, How do I get ricin poisoning?

377 00:28:02.630 --> 00:28:06.049 Well, most exposures to rice and or accidental.

378 00:28:06.049 --> 00:28:13.609 So the Castor plant produces beans and beans are often used in as ornamentation for jewelry or for home decoration.

379 00:28:13.609 --> 00:28:17.769 Most ricin exposure is from children or adults eating these beans,

380 00:28:17.769 --> 00:28:26.079 but the other way that you might be exposed to ricin is if you are the Anti Communist Bulgarian dissident Georgi Markov.

381 00:28:26.079 --> 00:28:33.640 And in if you are the Anti Communist Bulgarian dissident georgi Markov and you're in and you are in London,

382 00:28:33.640 --> 00:28:36.339 England on September 7th 1978.

383 00:28:36.339 --> 00:28:38.250 A Bulgarian Secret Service agent,

384 00:28:38.250 --> 00:28:45.130 aided by the KGB, stabbed you in the back of the leg with a murder umbrella containing ricin.

385 00:28:45.130 --> 00:28:52.769 Unfortunately, Georgi Markov died four days later of ricin poisoning and I hope that you personally are not Georgi Markov,

386 00:28:52.769 --> 00:28:55.682 but how did your guy actually die?

387 00:28:55.761 --> 00:28:58.500 Why was rice and able to kill him?

388 00:28:58.500 --> 00:29:01.930 Well, rice and is a protein that inactivates ribosomes,

389 00:29:01.930 --> 00:29:03.839 and when I say protein,

390 00:29:03.839 --> 00:29:06.140 you might be thinking of fish,

391 00:29:06.140 --> 00:29:08.799 eggs, cheese. Yogurt, that kind of thing,

392 00:29:08.799 --> 00:29:11.740 but as scientists, we think of proteins differently.

393 00:29:11.740 --> 00:29:13.950 We think of proteins as tools,

394 00:29:13.950 --> 00:29:18.740 and proteins are the tools that your cells need to survive an function.

395 00:29:18.740 --> 00:29:22.420 So the ribosome translates your genetic information into functional tools.

396 00:29:22.420 --> 00:29:28.299 So Emma talk to us about how cancer can happen if your genetic information is damaged,

397 00:29:28.299 --> 00:29:31.250 but if your genetic information is not damaged,

398 00:29:31.250 --> 00:29:37.913 what it usually does is it contains the information to make these tools are to make these proteins.

399 00:29:37.979 --> 00:29:42.779 So usually what happens is your genetic information goes into a ribosome,

400 00:29:42.779 --> 00:29:44.569 which is like a factory.

401 00:29:44.569 --> 00:29:48.759 The factory then translates that genetic information into a tool.

402 00:29:48.759 --> 00:29:56.619 What rice and does is rice in gets into this factory an clogs up the works and it prevents the ribosome from actually doing its job.

403 00:29:56.690 --> 00:30:00.250 So when Bryson gets into a cell the genetic information goes to.

404 00:30:00.250 --> 00:30:01.829 Ribosome, but then nothing happens.

405 00:30:01.829 --> 00:30:04.990 No tools are produced, and when no tools are produced,

406 00:30:04.990 --> 00:30:08.800 life stops and I would argue that that is a bad thing.

407 00:30:08.855 --> 00:30:14.150 But what's interesting is that the toxicity of rice and really depends on the route of exposure.

408 00:30:14.150 --> 00:30:16.049 So the LD 50 by Ingestion,

409 00:30:16.049 --> 00:30:20.160 or if you eat those Castor beans is only 25 milligrams per kilogram.

410 00:30:20.160 --> 00:30:25.529 For reference, that means that about five Castor Beans is enough to put you in the hospital,

411 00:30:25.529 --> 00:30:28.680 and may be enough to kill you.

412 00:30:28.680 --> 00:30:33.390 However, by injection. Like with your guy Barkov,

413 00:30:33.390 --> 00:30:38.299 the LD 50 is over 10,000 fold less than it is by Ingestion.

414 00:30:38.299 --> 00:30:41.329 It's only .006 milligrams per kilogram by inhalation.

415 00:30:41.329 --> 00:30:44.730 It is similarly small, at .004 milligrams per kilogram.

416 00:30:44.730 --> 00:30:49.269 But the good news is that most ricin poisoning victims actually survive.

417 00:30:49.269 --> 00:30:53.420 So by Ingestion, which is the most common route of exposure,

418 00:30:53.420 --> 00:30:56.069 most patients will recover within a month.

419 00:30:56.069 --> 00:31:00.980 However, if your Yorkie Markov and you've been injected by a murder umbrella,

420 00:31:00.980 --> 00:31:04.420 you will probably die within days.

421 00:31:04.420 --> 00:31:08.130 So we've talked about two poisons that are most definitely harmful,

422 00:31:08.130 --> 00:31:10.150 but poisons can also be useful.

423 00:31:10.150 --> 00:31:13.859 So every medication that you've ever taken is actually a poison.

424 00:31:13.859 --> 00:31:20.259 You just take it at a dose that is low enough that it helps you rather than hurting you.

425 00:31:20.259 --> 00:31:22.960 The two poisons that we talked about today,

426 00:31:22.960 --> 00:31:27.339 botulinum toxin and ricin are actually being used right now to solve problems,

427 00:31:27.339 --> 00:31:34.799 so you might remember that in the beginning I told you that Botox has an LD 50 of one nanogram per kilogram.

428 00:31:34.799 --> 00:31:41.079 And then I told you that botulinum toxin also has an LD 50 of one nanogram per kilogram.

429 00:31:41.079 --> 00:31:43.180 That's because botulinum toxin is Botox.

430 00:31:43.180 --> 00:31:47.710 They are the same thing we inject the most poisonous substance on Earth,

431 00:31:47.710 --> 00:31:50.509 hands down into our faces to prevent wrinkles.

432 00:31:50.509 --> 00:31:54.000 So I'll let that sink in for a little bit,

433 00:31:54.000 --> 00:31:59.329 and. You can do with that information whatever you so choose.

434 00:31:59.329 --> 00:32:00.779 Racing on the other hand,

435 00:32:00.779 --> 00:32:03.099 is being used as a targeted cancer therapy,

436 00:32:03.099 --> 00:32:06.000 so rice, and because it's so effective at killing cells,

437 00:32:06.000 --> 00:32:08.319 if we can target rice into cancer cells,

438 00:32:08.319 --> 00:32:10.349 we can specifically kill those cancer cells,

439 00:32:10.349 --> 00:32:12.089 which I think is pretty cool.

440 00:32:12.089 --> 00:32:14.410 So now you might be thinking to yourself.

441 00:32:14.410 --> 00:32:16.150 OK, this is great and all,

442 00:32:16.150 --> 00:32:24.559 but what about radiation? You know you mentioned uranium in the beginning and you know you told me that if I ate a Cup and a half of uranium,

443 00:32:24.559 --> 00:32:26.589 I would die. And it also like.

444 00:32:26.589 --> 00:32:30.579 Why would I ever eat a Cup and a half of uranium?

445 00:32:30.579 --> 00:32:32.299 What's going on there? Well,

446 00:32:32.299 --> 00:32:39.500 Mike is going to tell us about some scientists who might not have eaten a Cup and a half of uranium,

447 00:32:39.500 --> 00:32:41.900 but they did do some pretty unsafe

448 00:32:41.900 --> 00:32:43.609 things. So, as Emma said,

449 00:32:43.609 --> 00:32:48.420 my name is Mike. I'm a fourth year graduate student in the pharmacology Department.

450 00:32:48.420 --> 00:32:52.880 In today, I'm going to tell you some stories about some scientists who,

451 00:32:52.880 --> 00:32:57.329 while they might not have ingested a Cup and a half of uranium,

452 00:32:57.329 --> 00:33:01.710 they did do some unsafe practices in pursuit of their science.

453 00:33:01.710 --> 00:33:06.680 So the three Sciences that I'm going to focus on our nuclear physics,

454 00:33:06.680 --> 00:33:13.930 organic chemistry and Biomedical Sciences and that last story will actually have a happy ending so with nuclear physics.

455 00:33:13.930 --> 00:33:25.390 The first thing. One might think about is radiation poisoning and what is what is radiation poisoning so if you're like me in your fan of the fallout video game

456 00:33:25.390 --> 00:33:29.210 series you might think that when you get radiation poisoning.

457 00:33:29.210 --> 00:33:31.589 You'll start growing extra limbs or.

458 00:33:31.589 --> 00:33:33.750 You might turn into a ghoul,

459 00:33:33.750 --> 00:33:37.710 however that's not really what radiation does to the human body,

460 00:33:37.710 --> 00:33:43.829 but to understand how radiation affects the human body we first need to understand what is radiation.

461 00:33:43.829 --> 00:33:46.349 So is Emma mentioned in her talk?

462 00:33:46.349 --> 00:33:52.829 The sun can emit UV radiation so it can emit enerji that can act on on your body.

463 00:33:52.829 --> 00:34:00.390 Well, there are other things like uranium and plutonium that can also emit radioactive enerji that can affect the human body,

464 00:34:00.390 --> 00:34:04.529 and there are several. Several different types of radiation.

465 00:34:04.529 --> 00:34:07.289 And depending on how strong the radiation is,

466 00:34:07.289 --> 00:34:10.739 depends on what type of things it can travel through.

467 00:34:10.739 --> 00:34:13.159 So for example there are Alpha Rays,

468 00:34:13.159 --> 00:34:15.570 which those can be blocked by paper,

469 00:34:15.570 --> 00:34:17.300 and they're not very strong,

470 00:34:17.300 --> 00:34:20.059 but there are other things like Gamma Rays,

471 00:34:20.059 --> 00:34:22.820 which is what made the Hulk X Rays,

472 00:34:22.820 --> 00:34:27.300 which what can be used to look at your bones and neutron raise,

473 00:34:27.300 --> 00:34:32.480 which can be emitted from radioactive materials like uranium and plutonium that are very strong,

474 00:34:32.480 --> 00:34:35.210 and these are called ionizing radiation.

475 00:34:35.210 --> 00:34:37.329 And So what is ionizing radiation?

476 00:34:37.329 --> 00:34:41.940 While to understand that we have to 1st understand what an Atom is,

477 00:34:41.940 --> 00:34:45.829 so atoms are the smallest unit of a chemical species there,

478 00:34:45.829 --> 00:34:49.719 composed of a nucleus which has protons which are positively charged,

479 00:34:49.719 --> 00:34:52.650 and neutrons which are neutrally charged.

480 00:34:52.650 --> 00:34:54.469 Around the nucleus are electrons,

481 00:34:54.469 --> 00:35:01.559 and those are negli negatively charged and they balance out the charge from the Protons.

482 00:35:01.559 --> 00:35:06.320 So if a wave of energy comes in contact with an Atom.

483 00:35:06.320 --> 00:35:11.739 It can hit an electron and knock the electron away from the nucleus.

484 00:35:11.739 --> 00:35:17.579 When this happens the nucleus will lose a negative charge and become positively charged.

485 00:35:17.579 --> 00:35:21.329 This resulting positively charged Atom is called an ion,

486 00:35:21.329 --> 00:35:30.090 which is why this radiation is known as ionizing radiation and this is the radiation that comes from uranium and plutonium.

487 00:35:30.090 --> 00:35:34.679 So now what really happens when your body gets radiation poisoning.

488 00:35:34.679 --> 00:35:37.230 So as Emma talked about before.

489 00:35:37.230 --> 00:35:39.440 Radiation can cause breaks within your DNA,

490 00:35:39.440 --> 00:35:43.530 and that's exactly what happens when you get hit with radiation from uranium.

491 00:35:43.530 --> 00:35:45.739 These brakes can result in several things,

492 00:35:45.739 --> 00:35:50.780 so the first that we already learned about is that it can result in cell death,

493 00:35:50.780 --> 00:35:55.820 specifically in necrosis, and this is what happens when you get radiation burns on your skin.

494 00:35:55.820 --> 00:35:57.710 The other thing that can happen,

495 00:35:57.710 --> 00:36:01.800 as was mentioned earlier, is that it can actually change your genetic information.

496 00:36:01.800 --> 00:36:04.010 When this happens, radiation can cause cancer,

497 00:36:04.010 --> 00:36:09.280 and so if we think about the many things that can happen to a person.

498 00:36:09.280 --> 00:36:11.110 On exposed skin you can get,

499 00:36:11.110 --> 00:36:12.639 as I mentioned, radiation burns,

500 00:36:12.639 --> 00:36:15.989 and actually there's an interesting story that goes along with this.

501 00:36:15.989 --> 00:36:19.039 So when you get radiation burns much like a sunburn,

502 00:36:19.039 --> 00:36:20.570 your skin will turn red,

503 00:36:20.570 --> 00:36:26.360 will at low levels of radiation your skin can turn what was used to be called a healthy glow,

504 00:36:26.360 --> 00:36:31.849 and so drinking water actually used to be irradiated and was given to people to make them healthier.

505 00:36:31.849 --> 00:36:34.289 But this was back in the early 1900s,

506 00:36:34.289 --> 00:36:39.920 so you don't have to worry about there being any radiation in your drinking water today.

507 00:36:39.920 --> 00:36:42.980 Other things that can happen include lung scarring,

508 00:36:42.980 --> 00:36:47.960 intestinal bleeding, and you can actually lose all of your white blood cells.

509 00:36:47.960 --> 00:36:55.190 And in the lab, scientists routinely use radiation to clear out the immune system of different organisms.

510 00:36:55.190 --> 00:37:01.340 Now I also mentioned that you can change the actual genetic code with radiation and this can cause cancer literally everywhere,

511 00:37:01.340 --> 00:37:04.570 and so now that we know what radiation into the body,

512 00:37:04.570 --> 00:37:06.909 let's learn about how we can measure radiation.

513 00:37:06.909 --> 00:37:13.360 We need to figure out how much radiation were being exposed to so we can know what's what could happen to us.

514 00:37:13.360 --> 00:37:16.869 So there are many different units in which radiation can be measured,

515 00:37:16.869 --> 00:37:19.800 but the one I'll focus on today is the Sievert,

516 00:37:19.800 --> 00:37:21.559 which is the biologically effective dose.

517 00:37:21.559 --> 00:37:27.190 So how much radiation it takes to actually cause those problems that I was talking about before?

518 00:37:27.190 --> 00:37:32.739 The instrument that scientists use to measure radiation is called a Geiger counter.

519 00:37:32.739 --> 00:37:38.400 And so we'll just take a brief look at different doses and what those can do to you.

520 00:37:38.400 --> 00:37:45.150 So routinely, radiation is actually measured in Milli Sieverts which are a thousandth of a Sievert.

521 00:37:45.150 --> 00:37:48.949 Here's a scale of some different exposures of radiation.

522 00:37:48.949 --> 00:37:56.880 So at 10,000 Milli Sievert this amount of radiation would be fatal to most humans within weeks.

523 00:37:56.880 --> 00:37:58.840 At half that dose at 5000,

524 00:37:58.840 --> 00:38:00.469 we reach the LD 50,

525 00:38:00.469 --> 00:38:05.030 which is Elizabeth just told us is the amount of radiation at which 50%

526 00:38:05.030 --> 00:38:07.469 of the population would die.

527 00:38:07.469 --> 00:38:10.050 At less than that at 1000 Milli Sievert,

528 00:38:10.050 --> 00:38:14.920 we hit the point at which you start experiencing radiation Burns in Nausha.

529 00:38:14.920 --> 00:38:18.369 At 350 Milli Sievert, that's the exposure of Chernobyl residents.

530 00:38:18.369 --> 00:38:22.179 After the time of the sure Noble disaster.

531 00:38:22.179 --> 00:38:29.590 Much lower than that number we come to 10 Milli Sievert which is what your body gets during a full body.

532 00:38:29.590 --> 00:38:32.059 See T scan even lower than that.

533 00:38:32.059 --> 00:38:38.420 We get 0.4 zero point 1 and 0.001 milli Sievert which is what you receive during a mammogram.

534 00:38:38.420 --> 00:38:40.889 Chest X Ray or dental X-ray respectively.

535 00:38:40.889 --> 00:38:50.420 And so as you can see from these routine medical exams the radiation you're getting is upwards of 50,000 times less than the LD 50 for radiation.

536 00:38:50.420 --> 00:38:52.889 So to put this into context.

537 00:38:52.889 --> 00:39:00.019 You would need to get 500 full body CT scans all at once without stopping to reach the LD 50 of the radiation.

538 00:39:00.019 --> 00:39:06.840 So the next time you need to get a full body see T scan or an X Ray for a broken bone.

539 00:39:06.840 --> 00:39:09.630 Don't worry about the radiation you get exposed to,

540 00:39:09.630 --> 00:39:16.579 it won't do anything. Now I'm going to get into the stories about scientists who have,

541 00:39:16.579 --> 00:39:19.130 unfortunately, perished in pursuit of their work,

542 00:39:19.130 --> 00:39:24.219 and one of the most famous cases of this was during the Manhattan Project,

543 00:39:24.219 --> 00:39:32.230 which was a secret government program that the in which the United States developed the first atomic weapons during the Manhattan project,

544 00:39:32.230 --> 00:39:34.780 scientists were trying to control nuclear fission.

545 00:39:34.780 --> 00:39:41.329 So what is nuclear fission and nuclear fission occurs when substances like uranium and plutonium emit their energy,

546 00:39:41.329 --> 00:39:46.159 the energy that submitted. Then strikes another piece of uranium or plutonium,

547 00:39:46.159 --> 00:39:55.840 which splits that Atom, releasing another piece of energy which can then go on to split other atoms in a chain reaction.

548 00:39:55.840 --> 00:39:58.619 There are two words that are important when we talk about fission,

549 00:39:58.619 --> 00:40:01.230 and those are critical in super critical.

550 00:40:01.230 --> 00:40:07.239 In a critical mass, this breaking apart of atoms is self sustaining and constant.

551 00:40:07.239 --> 00:40:19.679 In a super critical situation the rate of fission events actually increases overtime and so you get more an more energy released as time goes on.

552 00:40:19.679 --> 00:40:24.900 So the first story that I'm going to tell you about today involves Harry Daghlian,

553 00:40:24.900 --> 00:40:27.340 who's actually born right here in Waterbury,

554 00:40:27.340 --> 00:40:39.391 CT. So when he was 19 he went off to go study nuclear physics at MIT and once there he was recruited by the US government to work on the

555 00:40:39.471 --> 00:40:43.539 Manhattan Project. His job was to build a neutron reflector,

556 00:40:43.539 --> 00:40:46.150 a neutron reflector. As the name implies,

557 00:40:46.150 --> 00:40:50.349 reflects neutrons to increase radioactivity of substances that surrounds.

558 00:40:50.349 --> 00:40:55.550 The way that this works is you can imagine if you have a small piece of uranium,

559 00:40:55.550 --> 00:40:57.690 there would be neutrons that would leave,

560 00:40:57.690 --> 00:41:06.260 and because it's so small they would just completely leave the metal and wouldn't be able to react with any other atoms and cause more neutrons to happen.

561 00:41:06.260 --> 00:41:08.710 If we used a bigger piece of uranium,

562 00:41:08.710 --> 00:41:11.159 those neutrons released would be more easily captured,

563 00:41:11.159 --> 00:41:14.860 could strike other atoms and keep the reaction going.

564 00:41:14.860 --> 00:41:20.800 Now the issue here is you would need an unreasonably large amount of uranium to make something like a nuclear weapon,

565 00:41:20.800 --> 00:41:29.289 and so the US government wanted to make reflectors that would trap these neutrons so they could use a small a piece of uranium as possible to make the biggest

566 00:41:29.289 --> 00:41:33.829 boom as possible. So one day in the lab,

567 00:41:33.829 --> 00:41:39.219 Daghlian was stacking reflectors around a plutonium core and the plutonium core is what's actually radioactive.

568 00:41:39.219 --> 00:41:42.260 As he was stacking these reflectors one by one,

569 00:41:42.260 --> 00:41:52.369 he got to the point where he was about to add one more reflector in his Geiger counter went off telling him that the plutonium core was going to reach

570 00:41:52.369 --> 00:41:58.260 a critical state. Realizing that this would not be good for his health,

571 00:41:58.260 --> 00:42:03.679 he decided that he was going to move that reflector away from the core.

572 00:42:03.679 --> 00:42:08.320 Unfortunately, his hand slipped and he dropped the reflector onto the core,

573 00:42:08.320 --> 00:42:14.130 which immediately made the core go critical and he was exposed to 5000 Milli Sievert.

574 00:42:14.130 --> 00:42:17.400 The LD 50 within seconds.

575 00:42:17.400 --> 00:42:20.519 He got radiation burns on all of his exposed skin,

576 00:42:20.519 --> 00:42:27.070 went into a coma and unfortunately died 25 days later and his death was the first death of the Manhattan Project.

577 00:42:27.070 --> 00:42:29.260 Now unfortunately, it was the first death,

578 00:42:29.260 --> 00:42:32.179 but it was not the last.

579 00:42:32.179 --> 00:42:34.360 His coworker Louis Slotin, also met,

580 00:42:34.360 --> 00:42:37.280 met the same fate due to radiation poisoning.

581 00:42:37.280 --> 00:42:39.820 Interesting Lee by the same plutonium core,

582 00:42:39.820 --> 00:42:43.099 which before it killed two people was called Rufus,

583 00:42:43.099 --> 00:42:49.289 but after that was known as the demon core a little bit more threatening and so slow.

584 00:42:49.289 --> 00:42:56.199 And had this trick that he would perform on this core that became known as tickling the Dragons tail,

585 00:42:56.199 --> 00:43:02.880 and that's because he was playing with death as he would use this core.

586 00:43:02.880 --> 00:43:12.300 The plutonium core was separated into two halves in the two halves needed to make contact with each other for the whole court ago critical he would use a screwdriver

587 00:43:12.300 --> 00:43:16.699 to prop up one piece of the core so that it couldn't go critical.

588 00:43:16.699 --> 00:43:21.719 He was supposed to use plastic spacers to keep the two pieces of the core apart,

589 00:43:21.719 --> 00:43:23.920 but elected to use his screwdriver instead.

590 00:43:23.920 --> 00:43:29.880 One day, when he was showing off to his friends that he could separate the core using a screwdriver,

591 00:43:29.880 --> 00:43:35.360 his hand slipped the two pieces of course connected and he was exposed to 10,000 Milli Sievert.

592 00:43:35.360 --> 00:43:37.730 In a second, just to remind you,

593 00:43:37.730 --> 00:43:40.090 that's the exposure that's fatal within weeks.

594 00:43:40.090 --> 00:43:48.809 Doctors that treated him said he had 3D sunburn inside his body and he went into a coma and died nine days later.

595 00:43:48.809 --> 00:44:00.269 So there are other scientists have been exposed to radiation who haven't had as dramatic of deaths and some other famous radiant scientists include Marie Curie in Roslyn Franklin.

596 00:44:00.269 --> 00:44:04.610 So Marie Curie is most famous for discovering radium and polonium,

597 00:44:04.610 --> 00:44:07.380 and she also won two Nobel Prizes,

598 00:44:07.380 --> 00:44:13.300 and she's the only one to win two Nobel Prizes in two different scientific disciplines,

599 00:44:13.300 --> 00:44:18.440 and so Marie Curie would actually handle her radioactive specimens without any protection.

600 00:44:18.440 --> 00:44:21.369 She would carry them in her pockets.

601 00:44:21.369 --> 00:44:28.269 And she also would write in her notebook how they glowed at night when she put them away in drawers.

602 00:44:28.269 --> 00:44:30.690 In fact, her notebook, another research materials,

603 00:44:30.690 --> 00:44:36.239 are to this day, so radioactive that they're locked in LED volts.

604 00:44:36.239 --> 00:44:45.659 Roslyn Franklin Is another famous scientist you may know because she was the first one to get an X Ray structure of DNA,

605 00:44:45.659 --> 00:44:50.360 which helped Watson and Crick determine the three dimensional structure.

606 00:44:50.360 --> 00:44:53.360 She was exposed to large amounts of high-energy X-rays.

607 00:44:53.360 --> 00:44:59.019 These are much higher than the X Rays that are used in routine X-rays for broken bones,

608 00:44:59.019 --> 00:45:02.679 so you don't need to worry about this happening to you.

609 00:45:02.679 --> 00:45:12.670 But during her career she was exposed to so many X Rays that she unfortunately got aggressive breast cancer and died just months before the Nobel Prize was given out

610 00:45:12.670 --> 00:45:21.929 for her discovery. Now I'm going to switch gears and move from nuclear physics to organic chemistry where we have two stories.

611 00:45:21.929 --> 00:45:25.429 So the first is about a chemist name,

612 00:45:25.429 --> 00:45:36.693 Carl Williams. She'll. He was a chemist in the mid to late 1800s and back in those days chemists did not have the sophisticated instruments they have now to carefully

613 00:45:36.755 --> 00:45:40.679 characterize the compounds that they make.

614 00:45:40.679 --> 00:45:42.690 So instead of using these instruments,

615 00:45:42.690 --> 00:45:48.389 they use their senses in one sense that coral like to use was his sense of taste,

616 00:45:48.389 --> 00:45:52.789 and so he would taste every new chemical that he made.

617 00:45:52.789 --> 00:45:58.130 Unfortunately for Carl, some of the chemicals and elements that he discovered included Mercury and arsenic,

618 00:45:58.130 --> 00:46:03.489 all of which she would take a sample of as he discovered them.

619 00:46:03.489 --> 00:46:08.960 But probably what he's most famous for discovering is hydro floric acid.

620 00:46:08.960 --> 00:46:14.619 So some of you may be familiar with hydro floric acid because of its ability to dissolve almost anything,

621 00:46:14.619 --> 00:46:23.059 and it was actually used in episode of Breaking Bad to dissolve a body and then ended up dissolving the bathtub that the body was in.

622 00:46:23.059 --> 00:46:29.480 This is essentially what happened to Carl's insides appan tasting his new creation of hydrochloric acid,

623 00:46:29.480 --> 00:46:34.530 and he died due to complications with ingestion of this material.

624 00:46:34.530 --> 00:46:36.090 So for my next story,

625 00:46:36.090 --> 00:46:41.369 we're going to go back to your high school chemistry class and talk all about that bass.

626 00:46:41.369 --> 00:46:42.929 In this case turbula Thiem.

627 00:46:42.929 --> 00:46:47.900 Before we talk about Turbutt Ulithi am I want to remind you what a base is.

628 00:46:47.900 --> 00:46:54.079 So base is a chemical that has free electrons that can take hydrogen from its environment.

629 00:46:54.079 --> 00:46:57.659 Turbutt a lithium is a special type of base.

630 00:46:57.659 --> 00:46:59.650 It's a very reactive base,

631 00:46:59.650 --> 00:47:04.030 so reactive that it will rip hydrogens off of anything nearby.

632 00:47:04.030 --> 00:47:08.110 This includes water within the atmosphere around it.

633 00:47:08.110 --> 00:47:15.150 What happens when it pulls off this hydrogen is that it releases a massive amount of energy and because of this,

634 00:47:15.150 --> 00:47:17.159 when Turk butyl lithium touches air,

635 00:47:17.159 --> 00:47:19.840 it can spontaneously combust and cause large fires.

636 00:47:19.840 --> 00:47:24.409 If the amount of Turbula theme is large enough.

637 00:47:24.409 --> 00:47:29.530 Despite the fact that Tributyl Lithium can spontaneously combust when it touches air,

638 00:47:29.530 --> 00:47:38.849 it's routinely used in chemistry labs around the world because of its ability to deprotonate almost any chemical species.

639 00:47:38.849 --> 00:47:42.030 Sherry Sanji, a graduate student UCLA,

640 00:47:42.030 --> 00:47:48.800 found out first hand just how explosive turbula theme can be.

641 00:47:48.800 --> 00:47:54.849 She was setting up a routine chemical reaction but was using 160 milliliters of Tert Butyl Lithium.

642 00:47:54.849 --> 00:47:57.340 That's about half a glass of water.

643 00:47:57.340 --> 00:48:06.239 She was using a 60 milliliter syringe to transfer this large volume of Turbula Thiem into the reaction she had set up in her hood.

644 00:48:06.239 --> 00:48:10.159 Unfortunately, when she was when she pulled back on the plunger,

645 00:48:10.159 --> 00:48:20.449 the plunger came loose from the syringe and Turpial at the M spilled onto her clothes and was immediately in contact with the atmosphere.

646 00:48:20.449 --> 00:48:22.349 As it touched her close,

647 00:48:22.349 --> 00:48:27.349 it spontaneously combust, lighting her clothes and unfortunately her on fire.

648 00:48:27.349 --> 00:48:28.739 She was wearing no goggles.

649 00:48:28.739 --> 00:48:30.119 Are flame retardant lab coat,

650 00:48:30.119 --> 00:48:35.710 which are now standards in the field to try to avoid something like this from happening again.

651 00:48:35.710 --> 00:48:38.480 Her lab mates quickly tried to put the fire out,

652 00:48:38.480 --> 00:48:39.869 but it was too late.

653 00:48:39.869 --> 00:48:48.179 One of them even commented that the skin seemed to be separating from her hands because of the severe burns and she passed away weeks later in the hospital due

654 00:48:48.179 --> 00:48:50.670 to complications with the injuries that she had sustained.

655 00:48:54.059 --> 00:48:59.289 Now we're going to switch gears again and talk about a story in the Biomedical Sciences and this one.

656 00:48:59.289 --> 00:49:02.429 I promise you has a happy ending.

657 00:49:02.429 --> 00:49:09.940 We're going to talk about a doctor named Berry Marshall who is who is practicing in Australia.

658 00:49:09.940 --> 00:49:19.639 He was interested in studying gastritis or inflammation of the stomach and stomach ulcers that usually occur with gastritis.

659 00:49:19.639 --> 00:49:24.920 So for a long time it's been assumed that ulcers are result of stress.

660 00:49:24.920 --> 00:49:33.659 Berry Marshall didn't think So what he notice when he was treating people with stomach ulcers is that the ulcers seemed.

661 00:49:33.659 --> 00:49:35.840 To spread between people like an infection,

662 00:49:35.840 --> 00:49:39.260 and so he thought that it could actually be.

663 00:49:39.260 --> 00:49:46.510 A bacteria that was causing stomach ulcers and not just the stress of everyday life.

664 00:49:46.510 --> 00:49:57.099 So in the lab he took samples from patients who didn't have stomach ulcers and those who did have stomach ulcers and found that there was a specific bacteria called

665 00:49:57.099 --> 00:50:00.389 helicobacter pie. Laurie so he tried to publish his.

666 00:50:00.389 --> 00:50:02.820 Findings in several journals, but no one believed him.

667 00:50:02.820 --> 00:50:06.239 They still thought the ulcers were due to stress.

668 00:50:06.239 --> 00:50:11.130 To try to prove that the bacteria was really causing the stomach ulcers very,

669 00:50:11.130 --> 00:50:14.659 Marshall grew up a culture of the bacteria.

670 00:50:14.659 --> 00:50:25.110 Drank it and then waited to see what would happen within a week he developed the symptoms of gastritis and also started developing a stomach ulcer.

671 00:50:25.110 --> 00:50:29.530 Realizing that it was the bacteria that was causing the problem,

672 00:50:29.530 --> 00:50:37.179 he decided to take antibiotics to see if he could eliminate the bacteria and relieve his symptoms.

673 00:50:37.179 --> 00:50:39.949 Within two weeks the gastritis was gone.

674 00:50:39.949 --> 00:50:49.429 There is no sign of a stomach ulcer and that's why antibiotics to this day are the main course of treatment for stomach ulcers.

675 00:50:49.429 --> 00:50:52.389 Because of his findings, his persistence.

676 00:50:52.389 --> 00:50:54.570 In his want to drink bacteria,

677 00:50:54.570 --> 00:50:57.849 he was awarded the Nobel Prize for his discovery.

678 00:50:59.880 --> 00:51:01.510 So after all these stories,

679 00:51:01.510 --> 00:51:05.599 you might be worried about how dangerous science can be.

680 00:51:05.599 --> 00:51:13.469 But I'm here to tell you that the community has learned from the past mistakes of the scientists that I've talked about today.

681 00:51:13.469 --> 00:51:18.300 There is a wide number of things that scientists use to protect themselves in the lab,

682 00:51:18.300 --> 00:51:20.719 all of which are called personal protective equipment,

683 00:51:20.719 --> 00:51:23.440 which range from goggles to gloves to blast Shields.

684 00:51:23.440 --> 00:51:32.500 And because of this, science is actually safer than ever and you don't have to worry about any of the graduate students sharing their stories with you on this podcast.

685 00:51:33.239 --> 00:51:38.289 Hi everyone, my name is Amanda Lee's I am not a friend to anthropologist,

686 00:51:38.289 --> 00:51:41.179 but as a biological anthropologist I have friends,

687 00:51:41.179 --> 00:51:43.710 anthropology, training and I teach about it.

688 00:51:43.710 --> 00:51:46.960 Today I'm going to teach you about some friends,

689 00:51:46.960 --> 00:51:51.650 get their apology methods by walking through and solving some famous cases together.

690 00:51:51.650 --> 00:51:55.260 A friends against apologist is someone who deals with decompose,

691 00:51:55.260 --> 00:51:57.070 skeletonized disarticulated, and fragmented remains.

692 00:51:57.070 --> 00:52:01.039 Skeletonized means that there's no more soft tissue on the body,

693 00:52:01.039 --> 00:52:04.349 and disarticulated means that those bones are no longer.

694 00:52:04.349 --> 00:52:09.324 Held together by anything and can be found in different places,

695 00:52:09.385 --> 00:52:14.420 but friends again. Their apologists usually work in relationship with criminal investigations.

696 00:52:14.420 --> 00:52:22.750 Although forensic anthropologists and their methods have solved past mysteries like identifying the last remains of the Roman offs.

697 00:52:22.750 --> 00:52:24.940 The last Russian Imperial family,

698 00:52:24.940 --> 00:52:35.400 including Princess Anastasia, an help in identifying individuals from mass disasters like 911 Hurricane Katrina and every plane crash ever.

699 00:52:35.400 --> 00:52:41.300 Friends like anthropologist provide biological information about human remains to determine who the individual was,

700 00:52:41.300 --> 00:52:49.940 how they lived, and how they might have died the day to day life of a forensic anthropologists involves looking at bones,

701 00:52:49.940 --> 00:52:53.679 writing reports and providing those two criminal investigations.

702 00:52:53.679 --> 00:52:58.670 The questions that friends, again their apologists try to answer our.

703 00:52:58.670 --> 00:53:01.519 First of all, is the bone human second of all?

704 00:53:01.519 --> 00:53:03.519 Who was this individual? What's their age,

705 00:53:03.519 --> 00:53:08.349 and what's their sex? And how did this person live?

706 00:53:08.349 --> 00:53:10.490 What was their lifestyle like?

707 00:53:10.588 --> 00:53:14.320 And finally, how might they have died?

708 00:53:14.320 --> 00:53:18.300 So, so you're walking along in the Woods and you find a bone.

709 00:53:18.300 --> 00:53:22.579 The first thing you're going to want to know before you called the police.

710 00:53:22.579 --> 00:53:28.090 Or maybe the police will help you figure this out is whether or not this phone is human.

711 00:53:28.090 --> 00:53:33.289 The most common bone found in the Woods and reported to US officials is actually bear paws.

712 00:53:33.289 --> 00:53:36.960 All animals pretty much of the same set of bones like phalanges,

713 00:53:36.960 --> 00:53:42.159 your finger bones, they may have them in different proportions or in different orientations.

714 00:53:42.159 --> 00:53:46.360 You might know the saying form follows function.

715 00:53:46.360 --> 00:53:49.570 Well, this is a principle that applies to bone.

716 00:53:49.570 --> 00:53:52.789 In other words, the forelimb of a human dog,

717 00:53:52.789 --> 00:53:55.289 bird, Anna whale are all homologous structures.

718 00:53:55.289 --> 00:53:57.429 They all have the same bones,

719 00:53:57.429 --> 00:54:00.440 but they're shaped differently for their different functions.

720 00:54:00.489 --> 00:54:02.016 Humans use tools, dogs run,

721 00:54:02.081 --> 00:54:03.922 birds, fly, and whales swim.

722 00:54:03.994 --> 00:54:07.780 They all have the same bones that make up their arms.

723 00:54:07.780 --> 00:54:10.989 For someone who is trained to notice these differences,

724 00:54:10.989 --> 00:54:14.559 determining if bone is human or not is relatively straightforward.

725 00:54:14.559 --> 00:54:18.349 It gets a bit more complicated when remains are fragmented.

726 00:54:18.349 --> 00:54:21.010 Say if they've been put through wood chipper.

727 00:54:21.010 --> 00:54:25.340 To illustrate this, let's discuss the famous woodchipper case from Connecticut in 1986,

728 00:54:25.340 --> 00:54:28.010 Harley crafts was murdered by her husband Richard,

729 00:54:28.010 --> 00:54:29.670 who then froze her body,

730 00:54:29.670 --> 00:54:34.670 disarticulated it and fed it into a wood chipper on the shore of Lake Sore.

731 00:54:34.670 --> 00:54:38.000 This case was the inspiration for the plot of Fargo,

732 00:54:38.000 --> 00:54:39.659 an episodes of forensic files,

733 00:54:39.659 --> 00:54:41.329 law and order and bones.

734 00:54:41.329 --> 00:54:46.989 This case is famous not only because of the gruesome nature of the disposal of the body,

735 00:54:46.989 --> 00:54:52.239 but also because it was the first murder conviction in Connecticut without a body.

736 00:54:52.239 --> 00:54:54.250 On the shore of the Lake,

737 00:54:54.250 --> 00:54:55.929 police found a tooth Crown.

738 00:54:55.929 --> 00:54:59.610 Bone chips 2660. Bleached blonde human hairs an oh type blood.

739 00:54:59.610 --> 00:55:02.960 The blood type was Halley's and she bleached her hair.

740 00:55:02.960 --> 00:55:13.010 But in a court of law this wouldn't be enough for conviction even given the fact that Richard had purchased a freezer and rented a wood chipper and was seen

741 00:55:13.010 --> 00:55:16.030 with that wood chipper on the shore of Lake.

742 00:55:16.030 --> 00:55:21.929 Sore by a snowplow driver late in the night around like 1:00 o'clock in the morning.

743 00:55:21.929 --> 00:55:24.030 But they still need a body generally,

744 00:55:24.030 --> 00:55:27.329 so let's go back to that bear paw for a minute.

745 00:55:27.329 --> 00:55:29.429 Humans are able to rotate their thumbs,

746 00:55:29.429 --> 00:55:31.530 an though bears can use their paws,

747 00:55:31.530 --> 00:55:33.630 much like humans can use their hands.

748 00:55:33.630 --> 00:55:35.730 They don't have the opposable rotating thumb.

749 00:55:35.730 --> 00:55:44.730 Another thing that humans have that make our finger bones distinct are that we have nails and not claws like bears and our finger bones have distinct wide and flat

750 00:55:44.730 --> 00:55:53.489 tips among the bone chips at this site they recovered a human thumb bone and if I haven't convinced you that you'd be able to tell by its shape.

751 00:55:53.489 --> 00:56:00.199 But it was human. There was an accompanying nail that was covered in pink nail Polish.

752 00:56:00.199 --> 00:56:02.579 So what about the rest of the bone fragments?

753 00:56:02.579 --> 00:56:06.269 After all, a thumb does not necessarily mean a whole body or a murder.

754 00:56:06.269 --> 00:56:13.980 How can a friends account their apologists look at a bone chip and determine if it's from a human and not an animal?

755 00:56:13.980 --> 00:56:23.905 Bone has a dense outer layer called cortical or hard bone and inner poorest layer called trabecula or spongy bone human cortical bone is overall less dense than it is

756 00:56:23.976 --> 00:56:30.829 in animals. A typical human long bone has a cortical thickness of about 1/4 of the area of the bone,

757 00:56:30.829 --> 00:56:33.530 while and animals this makes up about half.

758 00:56:33.530 --> 00:56:37.230 Furthermore, there's a distinct shape to the structure of cortical bones,

759 00:56:37.230 --> 00:56:43.349 which a forensic anthropologists can examine under a microscope to determine if it's human.

760 00:56:43.349 --> 00:56:49.789 Now that we've determined that the bone fragments found on the shore of the Lake were human bone fragments,

761 00:56:49.789 --> 00:56:53.860 can we tell if the bones were put through a wood chipper?

762 00:56:53.860 --> 00:57:04.030 The medical examiner at the time decided that it would be a good idea to feed a pig carcass through the wood chipper to see if the Marks and size

763 00:57:04.030 --> 00:57:09.789 and shape of the bone fragments that resulted match the bone fragments they found by the Lake.

764 00:57:09.789 --> 00:57:14.000 Some of you might remember this occuring in an episode of bones.

765 00:57:14.000 --> 00:57:18.079 Where one of the characters was very excited about doing this experiment,

766 00:57:18.079 --> 00:57:24.199 the resulting story is that they were able to actually tell the marks on the bones matched perfectly.

767 00:57:24.199 --> 00:57:27.599 We now know how to determine if bone is human.

768 00:57:27.599 --> 00:57:29.639 If we have a full skeleton,

769 00:57:29.639 --> 00:57:33.380 there is a lot more that a forensic anthropologist can determine.

770 00:57:33.380 --> 00:57:37.800 Importantly, especially with skeletal remains is to find the identity of the individual.

771 00:57:37.800 --> 00:57:42.719 Specifically, what was their age and what was their sex.

772 00:57:42.719 --> 00:57:47.539 And now we're going to delve into the very sad case of Caylee Anthony,

773 00:57:47.539 --> 00:57:51.380 the remains of a juvenile child were found skeletonized.

774 00:57:51.380 --> 00:57:57.476 But I'm going to tell you how exactly forensic anthropologists were able to tell how old that skeleton was.

775 00:57:57.550 --> 00:58:02.360 There are two ways to determine how old an individual was at death.

776 00:58:02.360 --> 00:58:04.349 Dental irruption an epiphyseal union.

777 00:58:04.349 --> 00:58:16.260 We all have a set of adult teeth and baby teeth and we lose them angain them at particular ages there are charts that show the timings of these eruptions.

778 00:58:16.260 --> 00:58:20.489 The important thing here in this case.

779 00:58:20.489 --> 00:58:24.920 Is that children second molars typically emerge between 20 and 30 three months,

780 00:58:24.920 --> 00:58:27.309 which is how old Caylee Anthony was.

781 00:58:29.409 --> 00:58:31.500 Similar to the eruption of our teeth,

782 00:58:31.500 --> 00:58:40.059 are bones grow at a fairly dependable rate and there are similar growth charts that can aid in determining the age of the individual.

783 00:58:40.059 --> 00:58:43.039 You might have heard of the baby soft spot.

784 00:58:43.039 --> 00:58:46.679 Well, at juvenile skull isn't a lot more pieces than adults.

785 00:58:46.679 --> 00:58:51.980 Those soft spots are openings between the plates of bones where they meet are called sutures.

786 00:58:51.980 --> 00:58:57.059 These sutures fused together. As we grow larger in our brains develop.

787 00:58:57.059 --> 00:59:00.369 Similarly, most of our bones start out in more pieces.

788 00:59:00.369 --> 00:59:04.010 The tibia, for example, has a shaft and two epiphyseal ends,

789 00:59:04.010 --> 00:59:06.989 one at the top and one at the bottom.

790 00:59:06.989 --> 00:59:17.400 With age, these fuse to the shaft to form the long bone and overtime they become obliterated to where you can no longer see the junction.

791 00:59:17.400 --> 00:59:21.570 When we take a look at this stage of Fusion from the bones recovered,

792 00:59:21.570 --> 00:59:27.659 we can clearly see that there is no union and that the epiphysis at the bottom is missing.

793 00:59:27.659 --> 00:59:30.440 Indicating that the body was that of a 2 year

794 00:59:30.440 --> 00:59:32.789 old. With

795 00:59:32.789 --> 00:59:34.880 young individuals such as kaylie,

796 00:59:34.880 --> 00:59:40.309 forensic anthropologists would not be able to ascertain sex from her skeleton sex,

797 00:59:40.309 --> 00:59:47.000 not gender, cannot be determined with certainty until an individual is more fully developed in adults.

798 00:59:47.000 --> 00:59:50.760 Determining the sex from the pelvis is relatively uncomplicated.

799 00:59:50.760 --> 00:59:58.699 Females have a wider pelvis with a larger more circular shape for the passage of a baby sexual dimorphism,

800 00:59:58.699 --> 01:00:04.289 the physiological differences between. Males and females is not quite so simple in the skull.

801 01:00:04.289 --> 01:00:07.420 Like all things, sex is somewhat on a spectrum.

802 01:00:07.420 --> 01:00:10.550 Some men have more feminine features and vice versa.

803 01:00:10.550 --> 01:00:18.840 That being said, there are a number of distinct differences in the shape and features of the skull that can indicate sex.

804 01:00:18.840 --> 01:00:20.510 Just to name a few,

805 01:00:20.510 --> 01:00:25.829 in males the neck muscle attachment on the back of the skull is generally more defined.

806 01:00:25.829 --> 01:00:35.820 They have heavier brow ridges and if you feel behind your ears that bump there is called the mastoid process and men it is a lot more pronounced and pendulous

807 01:00:35.820 --> 01:00:38.440 than it is in females.

808 01:00:38.440 --> 01:00:43.130 Experts from the body farm in Tennessee were called in on this case.

809 01:00:43.130 --> 01:00:46.929 You may have heard of this big forensic anthropology center.

810 01:00:46.929 --> 01:00:56.429 They testified in court that human remains had at one time been decomposing in the back of Casey Anthony's car scientists at this another body,

811 01:00:56.429 --> 01:01:01.750 farms take human remains that have been donated and study them in different scenarios,

812 01:01:01.750 --> 01:01:07.070 which they document overtime. They have large acres of land dedicated to the study.

813 01:01:07.070 --> 01:01:09.349 They have human remains in refrigerators,

814 01:01:09.349 --> 01:01:12.769 in trunks of cars and Bury generally all over.

815 01:01:12.769 --> 01:01:17.150 They study the rates of decomposition be associated maggots and gases.

816 01:01:17.150 --> 01:01:20.530 And have provided crime scene investigators with really amazing resources.

817 01:01:20.530 --> 01:01:27.969 There are more secrets are bones can tell from beyond the grave than I could possibly mention here by studying human remains.

818 01:01:27.969 --> 01:01:33.369 Forensic anthropologists can answer questions about how the person lived and sometimes about how they died.

819 01:01:33.369 --> 01:01:39.119 Dental records more often than not provide the identity of the remains in the wood chipper case.

820 01:01:39.188 --> 01:01:44.869 The tooth Crown found on the shore of the Lake was matched to hell is dental records.

821 01:01:44.869 --> 01:01:47.079 She was a Danish flight attendant.

822 01:01:47.079 --> 01:01:53.690 And the unique filling found on the tooth Crown was made from materials that aren't used in the US,

823 01:01:53.690 --> 01:01:57.869 healed fractures in past X Rays are as much identifiers as tattoos.

824 01:01:57.869 --> 01:02:00.530 Bone builds up around the break.

825 01:02:00.530 --> 01:02:02.039 In a very unique callous,

826 01:02:02.039 --> 01:02:05.780 and this often remains for the rest of your life.

827 01:02:05.780 --> 01:02:08.500 If a missing person had broken their leg,

828 01:02:08.500 --> 01:02:13.260 playing soccer and human remains are found that have evidence of a healed break,

829 01:02:13.260 --> 01:02:18.750 then X Rays can help determine the identification due to the unique remodeling.

830 01:02:18.750 --> 01:02:23.559 Medical devices and surgical pins are even more useful in aiding identification,

831 01:02:23.559 --> 01:02:30.780 as most of these have serial numbers that can actually be traced back to the individual during life,

832 01:02:30.780 --> 01:02:34.389 your bones react to stress load and repetitive motions.

833 01:02:34.389 --> 01:02:36.800 For example, many women, myself included,

834 01:02:36.800 --> 01:02:42.409 have bunions. This is often caused by wearing poorly fitted shoes with pointed toes,

835 01:02:42.409 --> 01:02:45.219 but any occupation that requires repetitive motions,

836 01:02:45.219 --> 01:02:49.090 like ballet or baseball, can also alter your bones.

837 01:02:49.090 --> 01:02:52.909 So whether it's habits or age that causes changes like arthritis,

838 01:02:52.909 --> 01:02:56.380 your occupation and lifestyle can be written in your bones.

839 01:02:56.380 --> 01:03:00.909 And forensic anthropologists. Take note of all of it.

840 01:03:00.909 --> 01:03:11.530 And I know you're all wondering what about cause of death bones can be broken after death or postmortem and forensic anthropologists are trained to tell the difference between fractures

841 01:03:11.530 --> 01:03:15.070 that have healed or happened at the time of death.

842 01:03:15.070 --> 01:03:16.840 Or were like I said,

843 01:03:16.840 --> 01:03:20.909 postmortem after death. But there are different types of trauma,

844 01:03:20.909 --> 01:03:24.369 and all of these we've very distinct marks on bone.

845 01:03:24.369 --> 01:03:29.559 There's blunt force trauma, which is caused by a blunt object like a baseball bat.

846 01:03:29.559 --> 01:03:32.929 It usually causes a depression with radiating fractures.

847 01:03:32.929 --> 01:03:40.500 Then there is sharp force trauma which is caused by sharp objects like knives or swords or wood chippers.

848 01:03:40.500 --> 01:03:45.230 And then there is ballistic trauma which is caused by surprise,

849 01:03:45.230 --> 01:03:50.739 surprise gunshots. To explain a little bit more about one of these,

850 01:03:50.739 --> 01:03:53.820 we're going to talk about the assassination of JFK.

851 01:03:53.820 --> 01:03:59.289 Although there is a lot of debate surrounding the number of shooters involved in this case,

852 01:03:59.289 --> 01:04:06.485 it was friends account, their apologists that determined to the single shooter theory after examining the evidence of the bullet holes,

853 01:04:06.543 --> 01:04:10.920 there are specific physics involved in the shape and size of bullet holes,

854 01:04:10.920 --> 01:04:16.920 which can determine the angle and direction of a shot and the trajectory of a bullet.

855 01:04:16.920 --> 01:04:20.420 So the entrance wound is going to be smaller and more circular,

856 01:04:20.420 --> 01:04:24.000 and the exit wound. Is going to be larger,

857 01:04:24.000 --> 01:04:31.530 more irregular? An have babbling and what I mean by Beveling is that when the plug of bone is pushed out,

858 01:04:31.530 --> 01:04:38.000 the outside of the bone is going to be larger than the inside of the bone it creates.

859 01:04:38.000 --> 01:04:48.748 This really wonky shape, sort of like a funnel based on where the entrance wound is and the shape of the exit wound in some cases very very large pieces

860 01:04:48.820 --> 01:04:52.550 are blown off, especially when it's shot at an angle.

861 01:04:52.550 --> 01:04:57.269 Much like JFK skull, which the entire brain case was actually blow Nov,

862 01:04:57.269 --> 01:05:04.889 you're able to really see the direction of the shot and so when forensic anthropologists examined the reconstruction of JFK's remains,

863 01:05:04.889 --> 01:05:09.610 they determined that the shot could not have come from the Grassy Knoll,

864 01:05:09.610 --> 01:05:13.969 but that it must have come from behind and above him specifically,

865 01:05:13.969 --> 01:05:18.789 the 4th floor of the Texas School Book Deposit Ori.

866 01:05:18.789 --> 01:05:24.800 And I hope that I've sort of cleared up any of your conspiracies that might lie there in.

867 01:05:24.800 --> 01:05:28.480 I just wanted to leave you with this last final note.

868 01:05:28.480 --> 01:05:32.150 There are 206 bones, an 32 teeth in the human body.

869 01:05:32.150 --> 01:05:37.829 All of these have a story that they can really tell about who you were in life.

870 01:05:37.829 --> 01:05:39.500 Thank you for tuning into

871 01:05:39.500 --> 01:05:43.510 the this episode of the Yale Journal of biology and medicine podcasts.

872 01:05:43.510 --> 01:05:46.179 We hope that you enjoyed this special episode.

873 01:05:46.179 --> 01:05:49.320 If you are located in or near New Haven.

874 01:05:49.320 --> 01:05:52.550 Keep an eye out for future science at brewery events.

875 01:05:52.550 --> 01:05:55.780 Wherever you're located, keep an eye open for future podcasts.

876 01:05:55.780 --> 01:06:00.630 There are many people behind this podcast that you never get a chance to hear.

877 01:06:00.630 --> 01:06:09.989 Thank you to the Yale School of medicine for being home to the wide job man this podcast thank you to the Yale Broadcast Center for helping with recording,

878 01:06:09.989 --> 01:06:11.610 editing and publishing our podcast.

879 01:06:11.610 --> 01:06:13.869 Thank you to the YJBM editorial board,

880 01:06:13.869 --> 01:06:15.480 especially our editors in chief,

881 01:06:15.480 --> 01:06:19.849 Amelia Hallworth and Devon Wasche and the deputy editors for the death issue.

882 01:06:19.849 --> 01:06:26.320 Kelsie Cassell and Wei Ng. For more information on YJBM and our Podcast,

883 01:06:26.320 --> 01:06:36.900 please visitmedison.yale.edu/YJBM. Be sure to check out our Journal by searching Yale Journal of biology and medicine at pubmed.com.

884 01:06:36.900 --> 01:06:39.309 Thank you to the Yale Science diplomats,

885 01:06:39.309 --> 01:06:45.159 especially Hannah Weinberg Wolf of the fear PhD student in the psychology Department and Amanda Lee's committee,

886 01:06:45.159 --> 01:06:49.630 chair of Science at brewery for planning the live version of this event.

887 01:06:49.630 --> 01:06:51.690 For more information on why SD,

888 01:06:51.690 --> 01:06:55.480 please visit their website sciencediplomats.sights.yale.edu or check them out on Facebook.

889 01:06:55.480 --> 01:07:01.670 Finally, thanks to you for tuning into this episode of the Yale Journal of biology and medicine podcasts.

890 01:07:01.670 --> 01:07:03.730 We'd love your feedback and questions,

891 01:07:03.730 --> 01:07:07.599 so feel free to tell us your thoughts by emailing us.

892 01:07:07.599 --> 01:07:11.239 At yjbm@yale.edu, If you enjoyed our podcast,

893 01:07:11.239 --> 01:07:15.550 please share it on SoundCloud or Apple podcasts.

894 01:07:15.646 --> 01:07:17.643 Thanks for listening.