The neutron

In the 1920s physicists thought that everything was made of just two components: electrons and protons. The prevailing theory was that, in each atom, lightweight negatively charged electrons whizzed around a tiny dense nucleus that held heavy positive protons and some more electrons. Then, in the early 1930s, came a surprise. Physicists found that alpha-particle radiation could induce samples of the light element beryllium to give off some other form of radiation – one exceptionally good at knocking protons out of other elements. In 1932 the English physicist James Chadwick, working at Cambridge, repeated these experiments and found that he could explain the effects if the alpha particles were knocking other particles – each about as heavy as a proton, but with no electric charge – out of the beryllium nuclei. These neutral particles could in turn knock protons out of other elements.
For a while Chadwick thought that the 'neutron' was not a fundamental particle, but a tightly bound electron and proton. But by 1934 measurements showed that the neutron was slightly too heavy for that. Physicists had to live with a new basic ingredient of matter. Atomic nuclei are made not of protons and electrons, but protons and neutrons. The various isotopes (or versions) of a particular element, which have the same chemistry but different weights, all contain the same number of protons but different numbers of neutrons.
This discovery helped to drive the furiously rapid advances in nuclear physics of the 1930s. The neutron is the key to the nuclear chain reactions that drive power stations and explode atomic bombs: neutrons fly out like shrapnel from each nucleus when it splits, hitting other nuclei and causing them to break up too. They also have less violent uses now: as probes of the structure of matter, undeflected by the charges around atoms because of their electrical neutrality.

1. What difference in weight is there between a neutron, on the one hand, and a tightly bound electron and proton, on the other.
In Line.12 it says that meaurements showed the "neutron" was slightly too heavy to be a tightly bound electron and proton, from which it can be deduced that the weight of the neutron must be a little more than that of a tightly bound electron and proton... therefore:
a) A tightly bound electron and a proton are as heavy as a neutron.
NO - "as heavy as" means "having the same weight as",
b) A tightly bound electron and a proton are not quite as heavy as a neutron.
YES - "not quite as heavy as" means "slightly less heavy than" (this, of course, is exactly the same as saying the neutron is slightly heavier than a tightly bound electron and proton – it just expresses it the other way round)
c) A neutron is much heavier than a tightly bound electron and a proton.
NO "much heavier" means "a lot heavier"
d) A tightly bound electron and a proton weigh half as much as a neutron.
NO - "half as much" is considerably less than "slightly less heavy than"
e) A neutron weighs slightly over twice as much as a tightly bound electron and a proton.
NO - "slightly over twice as much as" is considerably more than "slightly heavier than"

2. What components make up an atom?
In Lines 1 to 3 it says that the atom consists of a nucleus with electrons circling around it. In Lines 13 and 14 it says that the nucleus consists of protons and neutrons – therefore:
a) Electrons and protons.
NO – neutrons are missing
b) Electrons, protons and neutrons.
YES – this is in agreement with what it says in Lines 1 to 3 and Lines 13 and 14
c) Neutrons and protons.
NO – electrons are missing

d) Electrons and neutrons.
NO – protons are missing
e) Beryllium, electrons, protons and neutrons.
NO – electrons, protons and neutrons are valid components of an atom, but beryllium is an element, not a fundamental particle, and thus is irrelevant.

3. Which of the following statements is, according to the information in the text, False?

a) Research in nuclear physics progressed very quickly between 1930 and 1940.
NO this is True – in Line 17 it says there were "furiously rapid advances in nuclear physics"in the 1930s.
b) James Chadwick did not realise at once that the neutron was a fundamental particle.
NO this is True – in Line it says "for a while Chadwick thought that the "neutron"... was.... a tightly bound electron and proton" (at "once" means "immediately"; "for a while" means "for a short period of time")
c) In 1929 physicists still believed that electrons and protons were the only components things were
made of.
NO this is True – in Lines 1 and 2 it says "In the 1920's physicists thought everything was made of ... electrons and protons"; 1920's = all the years from 1920 to 1929
d) The different isotopes of any given element, despite having the same chemistry, vary in weight.
NO this is True – in Lines 14 and 15 it says that the various isotopes of each element "have the same chemistry but different weights".
e) Atomic nuclei are made up of two components, both of which are electrically charged.
YES this is False – in Lines 1 & 2 it says that electrons are negatively charged, whereas protons are positively charged. In Line 9 it says that the particles subsequently to become known as neutrons have no electric charge. So, of the two components making up atomic nuclei, protons and neutrons, only one has an electric charge, not both.

4. Collisions between which of the following are crucial to a nuclear chain reaction?
In Lines 18 to 20 we learn that neutrons are the key to nuclear chain reactions, and that they fly out from each nucleus when it splits, and then hit other nuclei, causing them to split, too ("split" means "break up")... therefore
a) Atoms and atomic nuclei.
NO – this is not in agreement with what it says in Lines 18 to 20
b) Atoms and electrons.
NO – this is not in agreement with what it says in Lines 18 to 20
c) Electrons and atomic nuclei.
NO – this is not in agreement with what it says in Lines 18 to 20
d) Neutrons and alpha particle radiation.
NO – although in Lines 4 and 5 it says alpha-particle radiation is capable of knocking (what later were to become known as) neutrons out of atomic nuclei, in Lines 18 to 20 it is made clear that the crucial collisions are between neutrons and atomic nuclei.
e) Atomic nuclei and neutrons.
YES – this is in agreement with what it says in Lines 18 to 20

5. How could subjecting a sample of beryllium to alpha-particle radiation lead to protons being knocked out of some other elements?
In Lines 4 to 6 it says that physicists found that if they subjected samples of the element beryllium to alpha-particle radiation this would cause the beryllium to emit some other radiation - the nature of which was, at that time, unknown. This unkown radiation was, <u>in its turn</u>, very effective at knocking

protons out of other elements (which we can assume were placed in the proximity so that they were subjected to the unkown radiation). Lines 8 to 10 give Chadwick's explanation for this unknown radiation in terms of a new chargeless particle – the neutron. Thus according to Chadwick the mechanism by which the effect was occurring was as follows: alpha-particle radiation was causing neutrons to be released from the nuclei of the beryllium sample, and these neutrons, in their turn, were knocking protons out of other elements... therefore:

a) Neutrons in the alpha-particle radiation could knock protons directly out of the atomic nuclei of the other elements.

NO – the described mechanism involves alpha-particle radiation knocking neutrons out of the beryllium nuclei, and these neutrons, in turn, knocking protons out of other elements.

b) The alpha-particle radiation could knock protons out of the beryllium nuclei, which could in turn knock protons out of the other elements.

NO – the described mechanism involves neutrons, not protons, being knocked out of the beryllium nuclei.

c) The alpha–particle radiation could induce the beryllium nuclei to give off neutrons and these could then go on to knock protons out of the other elements.

YES – this is in precise agreement with the mechanism described in Lines 8 to 10.

d) The alpha-particle radiation could cause particles of light to be emitted from the beryllium nuclei, and these could in turn knock protons out of the other elements.

NO – this is nonsense, the notion of particles of light is of no relevance to the mechanism (the word “light” in Line 5 refers to the fact that the element beryllium has a small weight).

e) The alpha-particle radiation could neutralize the electric charge of the protons in the other elements, thus knocking them out.

NO – this is nonsense, the notion of neutralizing the electric charge of the protons is of no relevance to the mechanism.

Jumping genes

After gaining her PhD in botany at Cornell University, USA, in 1927, Barbara McClintock began to study the genetics of maize. At the time, most geneticists used the fruit fly as their ‘model’ organism, but maize was preferred at Cornell. The colour of the kernels on a cob of maize are a clear expression of its genetic inheritance, while the plant’s large chromosomes, which carry the genes, are easier to study under the microscope. And the slow maturation of maize allows the researcher more time to reflect on a genetic experiment.

By 1931 McClintock had shown that the exchange of genes during the production of germ cells – known as meiosis – is accompanied by an exchange of chromosomal material. The experiments are regarded as a milestone in the history of genetics, since they establish the link between chromosomes and genetic inheritance.

But McClintock is probably better known for her work on ‘jumping genes’. In 1941 she moved to the Cold Spring Harbor Laboratory in New York state, which was to become a famous gathering place for pioneers in molecular biology. Noting the occasional appearance of odd-coloured spots and splashes on the leaves and kernels of her maize plants, she began to wonder about mechanisms that controlled the genes for colour. She developed the idea that they were mobile genetic elements that could jump around the chromosome. When they jumped into a gene, they disrupted its switching on and off. The genome – the total complement of genetic material in a cell – was far more fluid than anyone had ever imagined.

When McClintock presented this work to the genetics community in 1951, she was met with blank stares and indifference – even whispers that she was a little mad. By the 1970s, however, McClintock’s mobile genetic elements, named ‘transposons’, had been discovered in a number of organisms. She was rewarded for her pioneering work with the Nobel Prize for Physiology or Medicine in 1983.

1. When did McClintock demonstrate that genetic inheritance and chromosomes are linked?
In Lines 1 and 2 it says that McClintock began her study of the genetics of maize after gaining her PhD in 1927. In Lines 7 to 9 it says that before 1931 she had carried out experiments on meiosis that are considered a fundamental step (milestone) in establishing the link between chromosomes and genetic inheritance... therefore
a) Before 1927.
NO – she did not begin her study of maize genetics until after gaining her PhD in 1927.
b) Between 1927 and 1931.
YES – this in agreement with what it says in Lines 1 and 2 and Lines 7 to 9
c) Between 1931 and 1941.
NO – she carried out the experiments on meiosis before 1931
d) Between 1941 and 1951.
NO – she carried out the experiments on meiosis before 1931
e) After 1951.
NO – she carried out the experiments on meiosis before 1931

2. How did other scientists first react to McClintock's ideas on jumping genes?
In Lines 19 and 20 it says that when McClintock presented her work on jumping genes "to the genetics community in 1951, she was met with blank stares and indifference – even whispers that she was a little mad"... therefore
a) They awarded the Nobel Prize for Physiology or Medicine to her.
NO – she did not receive the Nobel Prize for her work on jumping genes until 1983, thirty-two years after she had first presented it to the genetics community.
b) They invited her to work in the Cold Spring Harbor Laboratory.
NO – she had already moved to the Cold Spring Harbor Laboratory in 1941, ten years before she presented her ideas on jumping genes to the genetics community.
c) They rewarded her with a PhD at Cornell University.
NO – she gained her PhD at Cornell University in 1927, twenty-four years before she presented her ideas on jumping genes to the genetics community.
d) They congratulated her on her discovery.
NO – this is contradicted by the phrase "she was met with blank stares and indifference"
e) They did not take them seriously.
YES – this is confirmed by the phrases in Lines 19 and 20 "she was met with blank stares and indifference – even whispers that she was a little mad"

3. What work did McClintock present to the genetics community in 1951?
In Line 19 the word "this" in the phrase "...presented this work to the genetics community in 1951" refers to the work on 'jumping genes' described in the preceding paragraph (Lines 11 to 18). The essential idea of this work was that mobile genetic elements could jump around the chromosome. As a consequence, since its elements were more mobile, this meant the genome itself was more fluid (mobile) than anyone had thought possible up until then.
a) Work showing that genes contained elements that were more mobile than had previously been thought.
YES – this in agreement with what it says in lines 11 to 19.
b) Pioneering work conducted on the genetics community.
NO – McClintock conducted work on the genetics of plants, not on the scientists studying genetics (i.e. the genetics community)
c) Work showing that the genome contained much more fluid than researchers had hitherto believed.

NO – in Line 18 the word “fluid” is used as an adjective, meaning “flowing” or “mobile”; in choice (c), instead, the phrase “contained much more fluid” sees the word “fluid” being used as a noun, meaning “liquid”. It is clearly nonsense to say that McClintock's work showed that the genome contained more liquid.

d) Work revealing that meiosis and an exchange of chromosomal material occur at the same time.

NO – in Lines 7 and 8 it says that McClintock's work showing that “meiosis-is accompanied by an exchange of chromosomal material” was undertaken before 1931. The “But” at the beginning of the first sentence in Line 11 indicates a break with this theme of meiosis/chromosomal exchange and a shift to a new theme of work on “jumping genes”. The discussion developed through Lines 11 to 19 makes it clear that it was this work on “jumping genes” presented to the genetics community in 1951.

e) Work demonstrating that maize is more suitable for research purposes than the fruit fly.

NO – in Lines 1 to 3 it says that maize was preferred to the fruit fly in research at Cornell in 1927, there is no indication in the text that McClintock undertook work to demonstrate such suitability, or that she presented this work to the genetics community 24 years later.

4. Why was maize preferred to the fruit fly as a ‘model’ organism at Cornell University?

In Lines 3 to 6 various properties of maize are outlined. The fact that these properties are cited immediately after the phrase “maize was preferred at Cornell” implies that they are the reasons for maize being preferred to the fruit fly. The reference in Line 4 to maize's “large chromosomes” , and in Line 5 to its “slow maturation”, suggest that these are, respectively, larger and slower compared to the fruit fly's – therefore:

a) The fruit fly has smaller chromosomes than maize and grows more slowly.

NO – the comparison is correct regarding chromosome size, incorrect regarding growth rate.

b) The fruit fly has larger chromosomes than maize and grows more quickly.

NO - the comparison is incorrect regarding chromosome size, correct regarding growth rate.

c) The fruit fly doesn’t grow as quickly as maize and its chromosomes are larger.

NO – the comparison is incorrect regarding both growth rate and chromosome size.

d) Maize doesn’t grow as quickly as the fruit fly and its chromosomes are larger.

YES – the comparison is correct regarding both growth rate and chromosome size

e) Maize grows more slowly than the fruit fly and its chromosomes are not as big.

NO – the comparison is correct regarding growth rate, incorrect regarding chromosome size.

5. According to the idea developed by McClintock, what would have been the cause of the odd-coloured spots and splashes which sometimes appeared on the leaves and kernels of her maize plants?

In Lines 13 to 17 it says McClintock's idea for the mechanism controlling the genes for colour involved mobile genetic elements which could jump into a gene and disrupt its switching on and off. In line 21 it says that the name given to these mobile genetic units was “transpons” - therefore:

a) McClintock herself, because she had devised a wonderful mechanism for controlling the genes for colour.

NO – this is nonsense - in Lines 13 to15 it says the spots and splashes led McClintock to wonder (ask herself) about mechanisms controlling genes for colour; she developed an explanation of how this mechanism occurred in Nature.

b) Mobile genetic elements switching cells on and off and thus changing their colour.

NO – in Line 16 and 17 it says mobile genetic elements disrupted the switching on and off of genes, not of cells.

c) The total complement of genetic material in one cell flowing into another cell.

NO – in Lines 16 to 18 its says only “genetic elements”, not the entire genome, were mobile; furthermore it implied these elements were only mobile between the chromosomes of a single cell, not from one cell to another.

d) Chromosomes jumping around from one maize plant to another.
NO – in Lines 15 and 16 it says that mobile genetic elements could jump around a single chromosome (by implication, within a single cell); it is nonsense to suggest that chromosomes could jump from one maize plant to another.
e) Transposons disrupting the functioning of the genes for colour.
YES – this in agreement with what it says in Lines 13 to 17 and Line 21.

KEYS:
The neutron

1. b 2. b 3. e 4. e 5.c

Jumping genes

1. b 2. e 3.a 4. d 5. e

Grammar questions

1. c 2. a 3. b 4. a 5. e 6. e 7. d 8. a 9. c 10. d 11. d 12. a 13. i) b ii) b 14. a 15. e 16. i) b ii) c 17. i) a ii) c 18. e 19. d 20. c