Findings in Chimpanzee Droppings Lead Scientists to Evolutionary Discovery

Case Study

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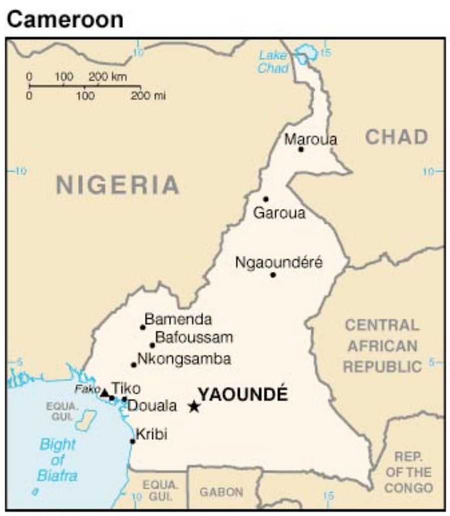
<u>Part I</u>

Far in the remote western African jungles of Cameroon (see map below; from http://www.state.gov/cms_images/map_cameroon.jpg), Dr. Beatrice Hahn and her team of scientists have been examining chimpanzee droppings. Chimpanzee primates typically travel in groups with one another sleeping in trees at night. Often, droppings can be easily collected at these sleep sites as the chimp troop, in the morning, may move on to continue foraging elsewhere in the forest.



What types of data might Dr. Hahn and her associates from the University of Alabama in Birmingham be studying? Explain your thoughts.

Part II

Chimpanzees, members of the great ape family, live in societies where they move in troops from one area to another searching primarily for vegetation and berries to consume. At times, they can also hunt cooperatively with one another to attack and kill monkeys, such as the red colobus monkey. In this way chimpanzees are like humans in that they are omnivores. In general, however, chimpanzees are typically "peace-loving"; however, they have been known to engage in warfare with neighboring troops. This can occur if a neighboring troop enters the territory of another troop. Each troop is very close with membership typically made up of mothers, their offspring, and several males. There tends to be one dominant male who is in charge of the group overall and typically has access to all females during estrus (time when females are fertile). Sometimes there can be internal turmoil as some juvenile males try to take over as the dominant male, but again, typically, the troops are very stable.

Over seven years, Dr. Beatrice H. Hahn, a virologist at University of Alabama in Birmingham, has led an international team of European and Cameroonian scientists to test hundreds of chimpanzee droppings. Using test tubes containing a preservative, the scientists collected 599 fecal samples from 10 forest sites and analyzed them in Dr. Hahn's laboratory weeks later.

The team was interested in tracing the evolution of HIV (human immunodeficiency virus) to solve the origins of HIV/AIDS. There is a simian virus, known as SIV (simian immounodeficiency virus) that is closely related to HIV and has been found in 23 species of African primates. The primates range from various species of monkey (e.g. Blue monkey, L'Hoest monkey) to mangabeys (e.g. red-capped mangabey), colobus, baboons, mandrills and chimpanzees.

SIV has also been found in captive Western chimpanzees, *Pan troglodytes troglodytes*, but researchers did not know if this was the same virus that was found in wild chimpanzees. This subspecies of chimpanzees lives in the wild in Cameroon, Gabon and the Congo Republic. If this virus was to be found in wild chimpanzees in one of these three countries, the scientists could identify the location where HIV evolved, as the SIV "jumped" from chimpanzees to humans (a process called zoonosis). This process was estimated to have occurred 50 to 75 years ago.

Questions

1. What is it about chimpanzee society that may have contributed to the spread of their virus?
2. If the virus found in captive Western chimpanzees is the same virus found in wild Western chimpanzees, how would you be able to verify this?
3. What might scientists gain from knowing the location of the evolution of HIV?
4. How might SIV have "jumped" from a chimpanzee to a human? What events would need to be in place?
5. What methodology might Dr. Hahn be using to detect the SIV in the fecal droppings? (*Hint*: it is the same way that we test humans for the presence of HIV)
6. What these researchers are engaged in can be described as field or basic science. What do you think this means? What value do you place in this type of research? Justify your thoughts.

Part III

If the virus found in captive Western chimpanzees was the same virus found in wild Western chimpanzees, Dr. Hahn and her associates should be able to detect the same molecular sequences for the virus. For example, if part of the virus genome in the captive chimpanzees reads "AUUCGAGGUAAC" then you would expect the wild virus' genome in this area to also read "AUUCGAGGUAAC."

In order to successfully jump from chimpanzee to human, SIV would need to evolve to be compatible with the human host (into what we now call HIV). In 2006, HIV affected 65 million people around the world, with the strain HIV-1 causing the vast majority of AIDS cases in the world. In addition to the virus evolving to move from chimpanzee to human, a successful means of transfer from a primate to a human would need to be established as well. For example, the blood of a chimpanzee might interact with a human who is cleaning the primate after killing it (for eating purposes – what is known as "bushmeat"). This hypothesis favored by Dr. Hahn's group suggests that SIV was transmitted to humans as a result of cutaneous or mucous membrane exposure to infected animal blood. Humans could also obtain the virus if they consumed uncooked contaminated meat. Dr. Hahn and another colleague, Dr. Gould, believe that the reason AIDS has appeared as an epidemic in the 20th century and not before is a combination of factors such as more roads for more access to forested areas, urbanization, prostitution, social disruption, and other socio-behavioral changes.

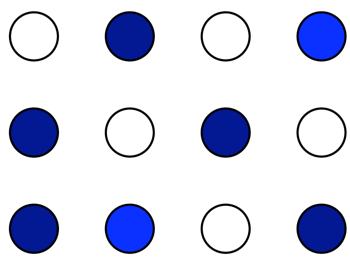
The competing hypothesis posed suggests that the poliovirus vaccination trials carried out in the Belgian Congo in the late 1950s were responsible for the zoonosis from primate to human. The primates at the forefront for zoonosis, the chimpanzee and the sooty mangabey, were not, however, used in vaccine preparation – rather the bonobos were used. In addition, a group of HIV-1 virus, known as the M group, has been estimated to have originated 10 to 50 years before the vaccine trials were conducted. For these reasons, the polio vaccine hypothesis is not accepted by most scientists today.

Still, we do know that the HIV evolved from SIV. When a virus evolves, its genetic material has changed. For example, when HIV evolves from one strain to another, its genetic make-up or its RNA is different. In this way, the human host cells do not recognize it and its immune system is not going to actually attack the virus. HIV and other viruses that are made up of RNA (rather than DNA) tend to mutate often and this is part of the reason our bodies have a tough time adapting to the virus. If we were to examine the genetic fingerprints of several strains of HIV we might see something similar to the below figure. Based on this figure, which two strains of HIV are closely related to one another? ___________ Which two are least closely related to one another? ___________

Sample 1: GACCTTACGGGATTCATA
Sample 2: GACTTAACGGGGGTCATA
Sample 3 : GACCTTACGGGTTACATA
Sample 4 : AACTACGTCAAGCACAGG
Sample 5: AACCTATCCCGATTCTAC

Such changes in genetic material in response to a **selective pressure**, in this case, the host cells response to the virus, are referred to as **microevolution**. The changes in the genetic material allow the virus to change, but not so much that we would consider it a separate species.

Dr. Hahn and her associates were looking for similar types of patterns between SIV and HIV. The way in which Dr. Hahn and her associates test for the presence of SIV in the chimpanzee droppings is to test for antibodies, proteins that are made to attach to the virus and help prevent them from causing further damage to cells. When we test for HIV in humans we do the same thing. Using a test called ELISA (Enzyme Linked Immunosorbent Assay), wells in a plastic plate contain HIV antigen to which a patient's serum is added. To obtain these samples, blood or saliva can be drawn. If the serum contains anti-HIV antibodies, they will bind to the antigen in the well. Next, a secondary antibody that recognizes the anti-HIV antibody is added. This secondary antibody has an attached enzyme on it. If HIV is present in the well, a noticeable change in color occurs in the well (see diagram below). We would then say this person has tested positive for HIV, but further tests would be employed for verification.



The above diagram represents an ELISA plate with its results. Each circle or well contains a different sample that has been treated (e.g. each well contains a sample from a person – so in this case, 12 people are being tested). If the well changes color (e.g. blue), the person has tested positive for HIV.

After testing for such antibodies, Dr. Hahn found evidence of infection with SIV in five of the ten field sites. The team found the prevalence was up to 35% in three communities; 4-5% in two communities; and none in five communities. This basic research can now be used to help foster applied science or research.

Questions

1. What is evolution? What conditions are necessary for it to "work?"
2. What is microevolution and how is this connected to a selective agent?
3. What does it say that the team of researchers found different prevalence of SIV in the different chimpanzee communities?
4. What is applied science compared to basic science? Which do you feel is more important to society? Justify your answer.

Work Cited

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Case Teaching Notes for
Findings in Chimpanzee Droppings Lead Scientists to Evolutionary Discovery

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Introduction/Background

This case study is an exploration of the evolution of HIV from SIV and how scientists approach problems. The overall goal is for students to get a sense of how questions and methods are employed in the field, the contribution of basic and applied science toward fostering our understanding of the natural world, and to read about a case examining evolution. This case study would be appropriate for an introductory biology course made up of non-majors, majors, or a combination. Depending on the class composition, you can elaborate or explore more fully the following topics: microevolution, selective agents, HIV versus AIDS, antibodies, the immune system and/or how cells work.

Objectives

Upon completion of the case, students should:

- Understand the difference between basic and applied science and realize the significance each contributes towards the field of science
- Understand how HIV could have evolved from SIV
- Be familiar with how HIV is detected in humans
- Get a sense of how biology is conducted in the field and consider experimental design
- Be able to discuss and understand evolution more fully

Classroom Management

The interruptive format of this case study allows for ample class discussion over two or more class periods if desired. For a 50-60 minute class period, I typically break up the class into smaller groups (of 3 or 4 students) and give each group Part I. After reading the section out loud (taking a volunteer from the class), I give the groups 5-10 minutes to discuss their answers. We then come back together as a class and discuss their thoughts. I will then pass out Part II and after group time, come back together as a class. At this point, a 50-60 minute class is usually out of time. You can pick up with Part III on day two. Alternatively, if would like the students to reflect individually on another section, you can give Part III as homework. I have done Part III in groups during class and as homework. Both work well. When giving Part III as homework, I will devote at least part of the second class to discuss what the students learned. This typically leads to more advanced discussions with the class and works well with the more advanced classes or students.

Answer Key

<u>Part I</u>

The scientists may be studying diet patterns of the primates – looking for digested products in the chimps' fecal matter. They could also be studying parasite prevalence and biodiversity. The scientists may also be studying the chemical make-up of the droppings to look for vitamin deficiencies. The scientists could also be looking for molecular data – e.g. they could be looking to trace the evolution of a virus.

Part II

1. *What is it about chimpanzee society that may have contributed to the spread of their virus?* Chimpanzees live in societies where they are in constant contact with one another, making the likelihood of a parasite or virus moving from one individual to another more likely. In addition, because chimpanzees engage in warfare and have been known to engage in cannibalism, the virus could be easily transmitted from one chimp to another.
2. *If the virus found in captive Western chimpanzees is the same virus found in wild Western chimpanzees, how would you be able to verify this?* The students come up with a variety of creative answers here, which typically leads to lots of class discussion. Eventually a group will argue that since a virus can only affect cells, the scientists have to study at the cellular level. Because viruses are not considered alive by many people (because they cannot reproduce without a host), students often argue that the virus should be studied from a molecular point of view. When the students get to this point, a discussion on similar genome composition is appropriate.
3. *What might scientists gain from knowing the location of the evolution of HIV?* If scientists learn the location of HIV evolution, they can study the chimpanzees more fully here to discover how much the virus has mutated and evolved over time. This would result in a more complete understanding of the virus and perhaps allow for another area of investigation to help further the knowledge base toward preventing HIV spread or evolution.
4. *How might SIV have "jumped" from a chimpanzee to a human? What events would need to be in place?* First the virus would need to adapt successfully to a human host. This requires that the virus evolve. Secondly, the virus would need a way to successfully move from a chimpanzee to a human.
5. *What methodology might Dr. Hahn be using to detect the SIV in the fecal droppings? (Hint: it is the same way that we test humans for the presence of HIV)* The students will likely come up with a variety of ideas for this question. This is an especially good question for discussion. I have asked students to put their thoughts up on the board so we could see the various creative ideas of the groups. By placing thoughts on the board, the other students can also see the value of brainstorming and that there are not necessarily "right" and "wrong" answers.
6. *What these researchers are engaged in can be described as field or basic science. What do you think this means? What value do you place in this type of research? Justify your thoughts.* Basic research is described as finding out knowledge for the sake of understanding a problem. For example, when Watson and Crick came up with their model of DNA, they wanted to understand this molecule's construction simply for the knowledge.

Part III

1. *What is evolution? What conditions are necessary for it to "work?"* Evolution is a change in the allelic frequency of a population. This can occur through a variety of mechanisms such as immigration/emigration, natural selection, genetic drift, etc. In order for evolution to occur, a population must be in place (individuals cannot evolve) because the allelic change occurs over time and generations. The trait under pressure must be heritable.
2. *What is microevolution and how is this connected to a selective agent?* Selective agents stimulate a change in a population. Examples of selective agents might include temperature, nutrient availability, presence of predators, etc. When the population changes in terms of the frequency of alleles in the population, we say that microevolution has occurred. Thus, selective agents stimulate microevolution.
3. *What does it say that the team of researchers found different prevalence of SIV in the different chimpanzee communities?* The community that shows 35% prevalence of SIV is

thought to be the area where SIV jumped to a human and became HIV. This area is located south of the Sangha River, which flows into the Congo River and on to Kinshasa, Congo. The earliest HIV infection was documented in 1959 in a Kinshasan man. Dr. Hahn's team has hypothesized that some infected person carried HIV from this area to Kinshas, where it was then passed on to other humans.

4. *What is applied science compared to basic science? Which do you feel is more important to society? Justify your answer.* Applied science builds on basic science and uses the information gained toward solving something. For example, because scientists understood what the DNA molecule looked like (from Watson and Crick's basic research), many applications have been possible. For example, the human genome project would not have been possible without knowing the basic structure of DNA.