Instructions between the field and the lab: collecting blood for the 'Serological Museum' in the 1950s

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Abstract

In a *Science* article published in 1953, Alan Boyden, a zoologist from Rutgers University and a pioneer in systematic serology, gave precise instructions on how to sample animal blood for the tissue collection that he housed in the Serological Museum. His instructions can be read as a 'prospective account' indicating the decisive shift in the history of the biological sciences towards the molecular level. It will be argued that Boyden's narrative points to some of the ambiguities that marked the changing relations between the field and the lab at the time. They were connected to the kind of actors involved in collecting, the objects that were assembled, the collecting practices and the role of the museum itself. It becomes clear that the Museum was to serve as a significance converter, opening novel avenues that contributed to turning the field into a resource for the laboratory as well as helping to ease the distance between the two.

Key words: Collecting, history of biology, Serological Museum, field, laboratory

Introduction

In July 1953, Alan Boyden, a zoologist from Rutgers University, published a short article in *Science.* Alan Boyden was a pioneer in systematic serology, the scientific study of blood serum, and specialized in the practice of classification, especially biochemical taxonomy.

Under the headline "Zoological Collecting Expeditions and the Salvage of Animal Bloods for Comparative Serology" he gave precise instructions on how to sample animal blood for scientific research. Boyden recommended the bleeding to be carried out during collecting expeditions and he expected the zoologists heading for field sites to send him their trophies in the form of soaked filter paper or in little bottles filled with liquid serum. With his call – which will be the focal point of this paper – he sought contributions to a previously unfamiliar biological materials collection. He tried to increase the number of samples that he kept in the "Serological Museum", which he had founded in 1948. Together with his colleagues, from the Bureau of Biological Research at Rutgers University, he intended to undertake a range of analyses with the blood that would contribute novel insight into animal systematics and classification.

Boyden convened an unusual corpus of material with his collection of animal bloods and plant sera. In the mid 20th century he found himself, like many researchers of the era, at a crossroads, where the phenotype of whole organisms and their morphology – corporeal characteristics like body height, hair, and eye colour – were in the process of losing their analytical predominance. When Boyden's article appeared in *Science* it tried to attract the attention of a broad range of scientists. The scholars he addressed did not share one and the same epistemic paradigm and thus debated the appropriate means of studying organic life. Therefore, one can assume, the practical knowledge that Boyden sketched in order to advise field researchers on how to gather samples also stood, in some way, for the changes that were drawing scientific attention toward the molecular level in the biological sciences. Furthermore, his narrative also pointed to the different kinds of knowledge practices that may have existed concurrently at the time.

From a museum and collection studies perspective, his account can be situated within two contextual strands that will help set the stage for analyzing Boyden's article in greater detail. The *first* of these strands has to do with traffic between the field site and the lab and the

intermediary status of a museum's collection. Coincidentally the laboratory came under scrutiny at about the same time as it began to develop into a novel form of 'big science' (Galison and Jones, 1999, 498) for the biological sciences. Through "in situ observation of scientific activity" (Woolgar, 1982, 482) scholars in the history and the sociology of science aimed to derive insight from the activities of scientists working in the lab.[1] At the same time, however, they have given much less attention to the ways in which collections were constituted and to the roles the objects and materials came to play between the field site and the laboratory. This corresponds to the biological researchers in these labs themselves. Historians Kuklick and Kohler write in their analysis of the relations between the field and the laboratory, that "… laboratory disciplines (have) tend(ed) to acquire corporate identities expressed in stable subcultures – and to forget the complexities of their historical origins" (Kuklick and Kohler 1996: 4). Thus, once the laboratory was established as a key place in science, its relations and interconnections to what lay beyond it were no longer scrutinized.

Accordingly, collections have long been understood as holding a pre-scientific status in relation to biological research (Kohler 2007: 428). Thus, with some exceptions (e.g. Kohler 2006, 2007, Macdonald 2006) few researchers have studied their contribution to scientific work, although one finds some interest from historians of science in museums. This was displayed by a recent journal *ISIS'* 2005 Focus (with for example Samuel Alberti on objects, Sophie Forgan on the museum building, Sally Gregory Kohlstedt on museums in operation contributing to a practice discussion). However, prevailing studies were rarely oriented toward analysing how collecting *practices* (Kohler, 2007, 429) contributed to the production of scientific knowledge. This applies especially for the second half of the 20th century onward, when from a historical point of view natural history museums have become seen as marginal (Rader & Cain 2008: 153). Since biobanking grew in popularity (Waldby and Mitchell 2006), however, it became clear that economical, political, social as well as scientific aspects of collecting had to be considered under new terms. Recent work reflects on how the body is dissected and looked into by drawing on anatomical displays (Hallam 2009: 69ff.) or discusses some of the circumstances and effects of banking biological materials such as cord blood (Waldby 2006).

In hindsight, it becomes clear that the remarkable case of Boyden's instructions refers to a scientific field that was in the process of a significant transformation. If I draw attention to Boyden's collection of blood and serum samples in this article, it is precisely to understand how collecting contributed to the emerging importance of the laboratory in the biological sciences and how actors, objects and practices were reconfigured in order to serve its means.

The *second* development that needs mentioning in order to position the following analysis can be linked to the shift of the biological focus from whole organisms toward an understanding of molecular mechanisms, which was connected to new ways of collecting. This change developed over the 20th century and was marked by an increase in experimentation (Allen 1978: xiv), the construction of complex experimental systems (Rheinberger 1997) and the elaboration of model systems (Birke *et al*.: 2007). The transformation has been widely debated in historical and sociological literature concerning its scientific significance. It has been referred to as "the molecular revolution" by Jordan and Lynch (Jordan and Lynch 1993[2]), but also more descriptively as the transition "from gross anatomy to the body's biochemistry and cellular structure" (Waldby and Mitchell 2006: 35) in the biological sciences.[3] While laboratories and experimental designs took on a central role in the realms of the biological sciences, it is far more open to question how collections were fitted into these reconfigurations of scientific work, how they were positioned in relation to novel epistemic endeavours (Gisler 2009) and what 'ways of knowing' (Pickstone 2001) emerged from them. One recent way of thinking this through refers to the Barcoding of Life Initiative. Ellis shows (2008) how museum specimens - in an age of DNA analyses - become alternative, though contested objects of re-classification.[4]

In this article I aim to shed light on how collections and collecting played a role in the shift from phenotype to genotype-based research by filling in the lacuna concerning the roles of the actors involved, their objects of desire, and their practical activities in the mid 20th century. I postulate that Boyden's endeavour may be read as a kind of indicator pointing to a scientific shift from the preoccupation with zoological knowledge organized around the classification of natural objects and their phenotype toward a molecular understanding of living organisms based on genotype and genetic programming. More concretely, in the following I suggest that the

instructions Boyden gave on how to collect animal blood can be understood as a recommendation for a novel way of dealing with the material components of living beings. With a focus on the significance of methodological advice, this article will enquire as to how collecting blood for the Serological Museum played a crucial role – not as a one-off, but as a quasi prototype - in the long passage toward modern biology.

In the first section, some background information will be given on the Serological Museum at the time it was founded. The methodological and the theoretical considerations on the meaning of instructions, as we find them formulated in Boyden's article, will, furthermore, be discussed. Next, Boyden's advice will be considered in detail with respect to whom he addressed and how these individuals were specified as future collectors, what was collected, what kind of practical instructions were given and how the Museum situated itself in a network of others. Finally, this analysis should contribute insights into the history of tissue collecting and the role it played during an important stage in the development of the life sciences.

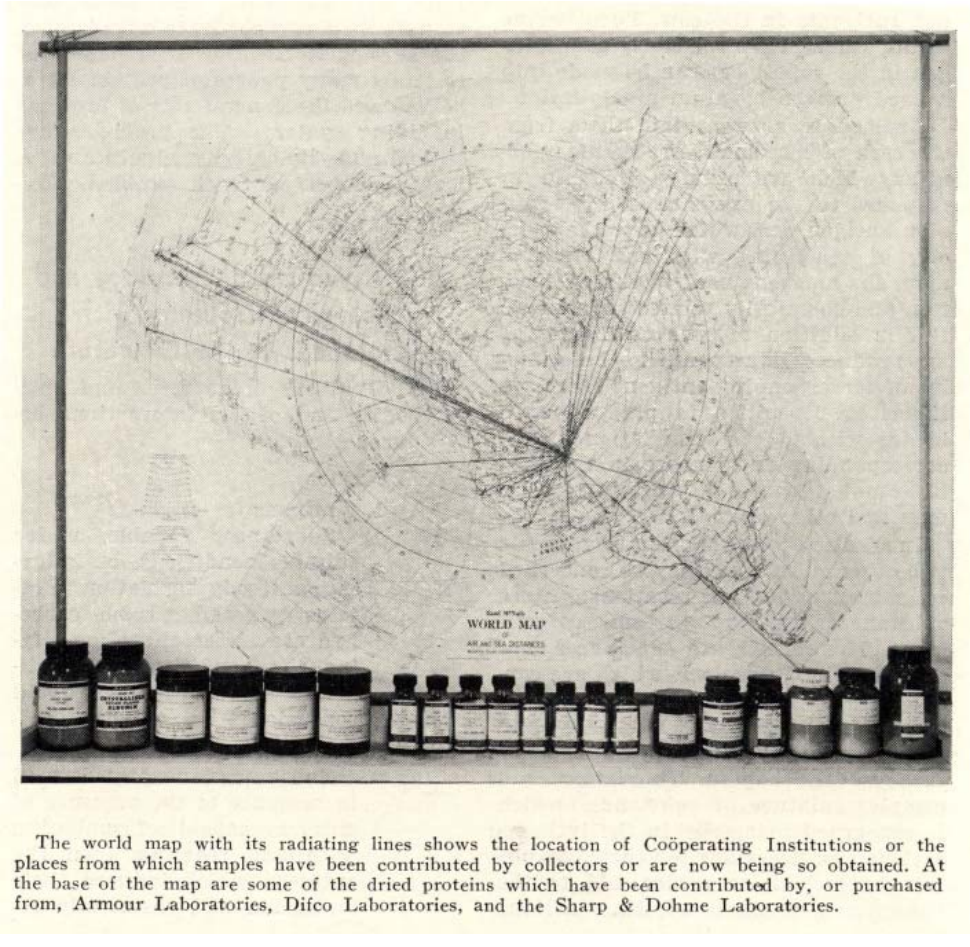
Setting the scene: The Museum of Serology as a 'World Centre for the Study of Comparative Serology'

> "The institution known as a 'museum' has evolved in historic times. At first it was a place to study – to muse – hence the appropriateness of the name **museum**. Later it became a place to study and to house the objects of study. And finally the museum has come to be popularly known as a place for exhibition. Fortunately, the problem of exhibition is of no great concern to us. Bottles of serum, fluid or dried, look like other bottles of serum. We shall not need great marble halls for the exhibition of our objects of study" (Boyden, Bulletin No. 7, Nov. 1951, 5).

The Serological Museum was founded in February 1948, following the end of the Second World War, and was part of the Bureau of Biological Research (author not specified, Bulletin No. 1, 1948, 2)[5] at Rutgers University. The scientific programme of the Museum was dedicated to the preservation and the characterization of blood constituents and to studies in the comparative serology of various groups of animals (author not specified, Bulletin No. 2, 1948, 20f.)[6] Its primary task was to improve the system of animal classification.[7].To enhance the visibility of his activities, Boyden started publishing a limited edition of the so-called *Bulletin of the Serological Museum*, which was first released shortly after the opening of the Museum.[8] The growing importance of the Museum became clear at the beginning of the 1950s. At this time, the Rockefeller Foundation and Rutgers University jointly donated the Museum a new *Cold Room* where the Museum's growing collection could be housed (Boyden, Bulletin No. 7, Nov. 1951, 5), whereas previously the collection was scattered across the University campus.[9] Together with the laboratory room next to the preservation area, the Museum (Figure 1) was hereafter attributed a clearly defined space not only to store and keep samples, but also to the serological study of the systematic collection of animal and plant proteins (ibid., 6).

A range of carefully selected personalities from high-ranking institutions supported the work of the Serological Museum. This international advisory council was constituted by ten members from natural history museums, zoological societies, private laboratories and schools of medicine based in the United States, Europe and Australia (author not specified, Bulletin No. 1, 1948, 2). In 1953, the network even increased, as over 60 research organisations all over the world were mentioned amongst the "Cooperating Institutions" (Allison, Bulletin No. 11, 1953, 2), later participating in a vigorous exchange of knowledge, persons and goods.

Significant support was given early on. Boyden received help from a range of parties, expanding the Museum's reach and influence. Amongst the officers of the Serological Museum, Boyden was accompanied by Douglas Gemeroy, elected Director of Research, Dr. Ralph DeFalco, a Secretary (author not specified, Bulletin No. 3, Nov. 1949, 4), and a number of staff that increased over the years. But, Boyden, unambiguously remained the leader of the endeavour. The collection he called a Serological Museum was his great passion, which he served for an unexpectedly long period of time.[10] Upon his retirement in 1962, Boyden was replaced by De Falco as Museum director, only to step back into the role of director in 1971, when De Falco died.[11]



The world map with its radiating lines shows the location of Coöperating Institutions or the places from which samples have been contributed by collectors or are now being so obtained. At the base of the map are some of the dried proteins which have been contributed by, or purchased from, Armour Laboratories, Difco Laboratories, and the Sharp & Dohme Laboratories.

Figure 1: Serological Museum world map with contributed samples

It should be kept in mind that the Serological Museum, despite its singularity, was only a really early example in a series of emerging collections, banks and repositories that were able to preserve bodily tissues. Not many before him – the biologist and parasitologist George Henry Falkiner Nuttall being a rare example – had tried to assemble and preserve bloods of various types. [12] Since the 1970s, however, researchers in the biomedical sciences increasingly gathered biological tissues, biochemical components, proteins, nucleic acids, etc. from animals and humans (Waldby and Mitchell 2006: 7) and thus changed the style of scientific collections. Boyden, at the end of his long career, did not know how many samples his collection embraced. Nonetheless, it was clear that his collection consisted of objects – blood and sera – that were far from what earlier exhibits used to have on display in natural history museums. The construction of three-dimensional exhibits showing blood relationships of animals such as dogs, sheep or cattle, which may have stood a Serological Museum well, were rare examples of what Boyden filled the storage rooms with.[13]

It remains difficult to judge the direct impact of Boyden's activities on other collectors. However, scholars from micro- and molecular biology took Boyden's achievements as a kind of starting point. Herbert Dessauer and Mark Hafner, for example, who saw themselves following in Boyden's footsteps in researching the preservation of organic tissue, recognized in the 1980s the Serological Museum as "the first formally organized collection of undenatured

tissues", confirming the pioneering role of Boyden and his colleagues (Dessauer and Hafner, 1984, 1).[14]

Much organizational and collecting work had already been completed when, in the *Science* article of 1953, Alan Boyden declared the Serological Museum to be "a kind of world centre for the study of comparative serology" (Boyden, 1953, 58) and positioned himself at its centre. Boyden expanded on the centrality and necessity of such a museum when, in the same article, he proudly announced that it had been designated "a Subsection of the Section of Zoology of the International Union of Biological Sciences" (ibid.) and, moreover, that it had already been declared the "reception agency for animal bloods and sera from all parts of the world by the U.S. Department of Agriculture" (ibid.). Thus, Boyden portrayed the collection – which in its configuration contradicted Boyden's naming it 'museum' - as an institutional hub for blood and sera of all sorts of organisms in the United States and worldwide (see Figure 2). In light of these announcements and proclamations, the analysis of Boyden's instructions may reveal something about how he tried to establish authority and to enlist as many participants as possible (Star and Griesemer, 1989, 389) to join him in the task of gathering a substantial and complete collection.

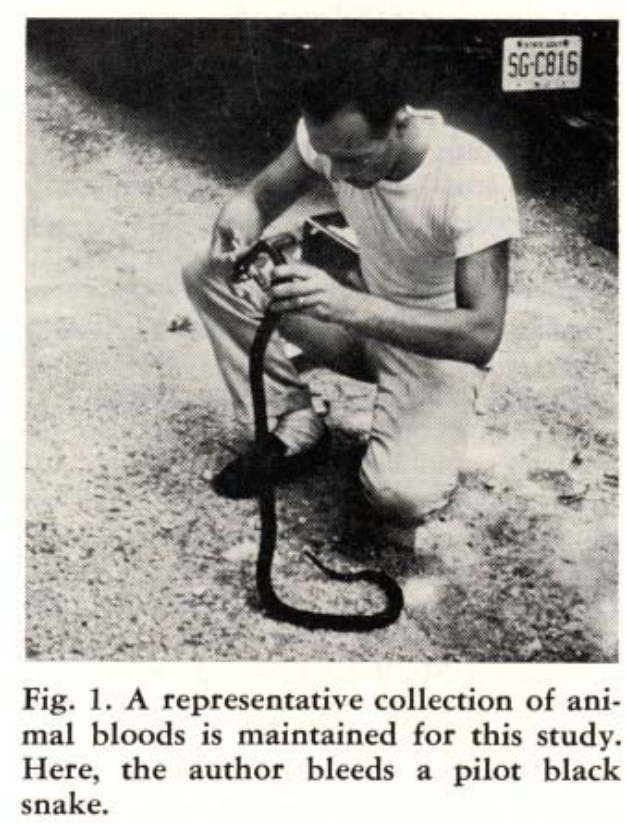


Fig. 1. A representative collection of animal bloods is maintained for this study. Here, the author bleeds a pilot black snake.

Figure 2. The bleeding process

An analysis of instructions: Some methodological and theoretical considerations

Boyden's account that addressed zoological collecting expeditions, published in *Science* in 1953, is by all measures worth closer inspection. Boyden tried to teach readers about how to save blood and to obtain sera from animals. His article will serve in the following as a type of documentary evidence, outlining his plan to realize an early and unusual tissue collection. Therefore, the evaluation that follows will take under close scrutiny Boyden's text and try to identify some of the early transformations that may have contributed to the routine use of laboratories and blood banking. It is based on Boyden's instructive guidelines to collecting blood and sera from animals in the field and how they should be sent back to the laboratory. While the instructions were written by a zoologist keen to persuade interested readers to follow his claims, they also had to be laid out quite explicitly for less informed readers. Its tone relied on a mixture of education and indoctrination. Boyden's article is therefore an outline of how collecting was supposed to take place in the name of blood protein analysis and serological work in the emerging biological sciences.

The moment Alan Boyden's collection took shape will be considered more closely via a micro-analytical approach. While, on the one hand, Boyden simply informs his audience about his keen interest in augmenting his collection, on the other, his text provides the researchers reading *Science* with the programme for the unquestionable existence and the undoubted necessity of such a thing as a Serological Museum. Therefore, the article can be analysed on a more descriptive, informative level but it can also be taken as a performative act that sets an agenda. While further historical material, including a range of scientific articles in *Science*, *Nature* and other journals, a file on the life of Alan Boyden, the thriving director of this museum, and the *Bulletin of the Serological Museum*[15], will provide enough context for the narrative, the instructions Boyden gave in *Science* will take centre stage and be read as a source suggesting how to think about the demise of phenotype and the rise of genotype in the life sciences.[16]

Concerning the analysis, it should be added, that instructions and regulations have long had a topical position in ethno-methodology. They have done so especially because of their incompleteness, ambiguity and indexicality (Amerine and Bilmes 1990: 324). The indeterminate nature and blurriness of written instructions assist in unclosing them to more general application (Jordan and Lynch 1998: 779) while the respective gaps and silences remain open for interpretation (Amerine and Bilmes 1990: 324). There are two theoretical points that render an analysis of Boyden's article from such a perspective especially promising.

First, propagating novel methods or tasks, as Star and Griesemer have pointed out (1989, 407), is a complex accomplishment. Instructions must be precise enough to be followed, yet they must also be kept simple enough to enlist and keep participants on track. The study of science and technology has taught us that scientific practices cannot be translated into written description without losing a degree of practical meaning. Conversely, it proves difficult to produce writing parameters that translate back into practice without intricacies. As Kaiser et al. write: "No amount of formal written instructions will suffice for producing the proper feel for the often recalcitrant instruments that populate the laboratory" (Kaiser *et al.* 2004: 879). Thus, an instructive text also provides a foil for an analysis of what is covered and what is left out. Therefore, in analysing Boyden's article, it will be revealing to consider which points he chose to focus on and what information he deemed necessary for sampling blood in natural environments that was eventually destine for processing and analysis at the Serological Museum.

Boyden's advice may be read as a kind of plan for novel practices and epistemic fields. Hence, *secondly*, the article also spoke to, and acted upon, potential future stakeholders in certain areas of the biological sciences. Certainly, although Boyden was a leading figure in systematic serology, he was not of importance in the debates about evolutionary biology or genetics that were important at the time. While he stuck to the notion of the 'museum', Boyden contributed with his collecting endeavour to preparing and laying the groundwork for a biology community that relied ever more on empirical evidence drawn from research on animals. When he began to define the objects of enquiry, he took part in the 'making for granted' of things that were going to inhabit the molecular world. Thus, what he wrote could be understood as a kind of a "prospective account" (Amerine and Bilmes 1990: 325) of a scientific field that was going to develop.

Against the backdrop of Boyden's knowledge about past collecting practices, his plans for the assemblage of biological materials and the organization of the Museum, the instructions he gave took on more obvious contours. The respective analysis points toward details and pieces that may have been omitted or ignored when they became routine taken for granted elements of daily practice. Instructions – whether they are followed or not – help frame a certain understanding about what should be done and about how actions should been undertaken. Corresponding with Amerine and Bilmes understanding instructions provide guidelines according which specific perceptions of a certain issue are constituted and competences are shaped. "Thus competence in dealing with instructions is at the same time a very situated competence in 'viewing the world,' or 'seeing what is there,' according to the account of things embodied in the instructions." (Amerine and Bilmes 1990: 329). How the world, according to a comparative serologist, should be viewed and what in Boyden's eyes, was there will be traced in the following analysis.

Boyden was obviously seeking support when he dedicated his brief article to "those who will be in a position to help" (Boyden 1953: 58). Hence, he came up with rather precise ideas about how blood had to be collected in the field, although the account spanned no more than two dense pages. While the accuracy of the instructions could not be proven outright, Boyden made it clear that he had personally exercised what he was describing many times before and thus he was very assertive in his outline in terms of what he expected, and prompted, his followers to do.

When Boyden published his plea to the scientific community in *Science*, he was already celebrating the "first five years" of the institution. He reminded himself and his audience of the need "for some central agency in the world to serve as a clearing-house for the studies in systematic serology, which were likely to develop in the next years" (Boyden, Bulletin 11, Nov. 1953: 6). Hence, with great effort, he tried to convince his readers of the importance of serology and to embed them into novel scientific endeavours. How his arguments were constructed, and which rhetorical figures he used, will be explored in the remaining sections, which set out to analyse his text more carefully.

Defining collectors – sharing the job: realigning roles in the name of comparative serology

Boyden used odd rhetoric in *Science* to address his fellow zoologists when he campaigned for the "Salvage of Animal Bloods for Comparative Serology" (Boyden, 1953, 57). Similar to a remote armchair anthropologist, and with missionary zeal, he seemed to hope that he would be able to build his collection from the gifts of others. However, far from being an anthropologist, he belonged to the first wave of researchers who classified plants and animals using blood serum proteins. Boyden worked in the field of systematic zoology and dealt with the classification of animals.[17] But when he called for the "attention of those planning and participating in zoological collecting expeditions" (1953, 57), he drew new classificatory lines around those that were interested in the animal kingdom.

Boyden spoke to those planning and participating in zoological collecting expeditions while he must have already known that the number of scientists working in this field had decreased (Kohler 2006). It seems clear that under such circumstances he had to address a broad camp of biological explorers. He thus focused on traditional zoological collectors as well as individuals who specialized in other fields of biology. In any case, he must have expected a large number of assistants. "It is our hope also that through the modest but considerate help of *many* individuals and expeditions it will not be necessary to organize special collecting expeditions to obtain the needed sera" (1953: 57). Therefore, as many people as possible were encouraged to collect the sera needed while Boyden aspired to transform the project into a collective endeavour. While eager to further enlarge the circle of collectors, in 1953, he proudly declared earlier successes. "Help has already been given us by many cooperating institutions and other agencies and by collectors in many parts of the world" (ibid.) (Figure 2).

Later on, specific mobile laboratory facilities were used to enable the sampling and handling of objects for analyses on a genetic level. But initially Boyden tried to integrate his zeal into existing endeavours while nonetheless aiming to reform the way sampling took place. For Boyden, it seemed clear that zoological collecting expeditions were short-handed, collectors had a minimum of time for extra duties, were "unequipped for refined serological collecting", and "inexperienced in the standard procedures for collecting and handling animal bloods" (ibid.). What these descriptions suggest is that collecting expeditions lacked manpower, time and the technical instruments that were needed for comparative serology. Boyden seemed to know what to expect from collectors and therefore what they actually had to acquire: competence and experience in applying the instruments and newest biochemical techniques used in the laboratories of serology and immunology. Yet, Boyden had two types of collecting situations in mind when he tutored potential helpers in blood sampling. *First*, he was speaking to a group of researchers in situations where "no facilities for collecting fluid blood are available" (ibid.), while for those in the *second* group a "minimum level of equipment" (ibid.) to gather blood assays might be at hand. In his paper, he treated those two groups differently.

In his carefully written article he linked the *first* group with the more traditional zoological

explorers in the field. Much more than the second group, he associated these members of expeditions with incompetence in handling materials by telling them, for example, “care should be taken to keep the paper fat free” (ibid.). He was furthermore considering cases where knowledge was lacking concerning the treatment of samples. Where “the identification is uncertain and the skin or other parts of the specimen are being preserved for later identification” he asked zoological explorers to “indicate the specimen number and institution” (ibid.), subtly suggesting the type of samples they were prone to collect. Thus he associated these individuals with the collection of phenotypical objects like skins or skeletons and stereotyped them as a group of naturalists that worked with simple, brute instruments. However, amongst the potential field collectors, the traditional naturalist that brought back collected animal trophies intact (Star and Griesemer 1989: 401) represented only one exemplary group. According to Boyden, individuals in the first group generally needed to be taught to better understand lab requirements.

But in the picture drawn by Boyden a branch of more experienced minds emerged as well. The *second* group received much more refined advice from Boyden since for these researchers containers for blood and preservatives were available. He treated these collectors as quasi experts and gave them information about amounts and concentrations of fluid materials and about the adequate mixtures needed for the preservation of samples. The only warning he gave to this group addressed issues related to temperature and blood clotting, which is understandable as freezers were rare and expensive at the time. To sum up, the more traditional collectors were associated with simpler sampling techniques while he also advised a kind of inexperienced expert group who were deemed to be more knowledgeable about the materials and technologies used in biochemical research at the time.

Addressing a wide community of zoological and biological researchers, the text illustrates the blurred lines between scientific and amateur activity in scientific fields (Kuklick and Kohler, 1996, 5). When Boyden spoke to an anonymous field of potential explorers, he differentiated between explorers with more or less equipment and skill. But while his discrimination remains somehow ambiguous, he did something else that drew on both groups. By continuously referring to the individuals in the field as helpers that were in need of instruction, he produced not only a division of labour amongst different collectors, and thus a hierarchy between the researchers collecting in the field, he also tied them more closely to the laboratory that was positioned at the centre, from where education and instruction would originate and where the analyses would be performed.

Furthermore, it becomes clear that the Serological Museum’s ‘way of knowing’ (Pickstone, 2001) would rely on centralized comparisons. The scientists that were willing to follow Boyden’s advice should not work upfront with the samples they collected. Even if they had knowledge about how the blood was going to be analysed, their analytical assistance was not desired: Only the comparison with existing samples in the laboratory, “an identification service” for example (1953, 58) would help to further classification and allow insight into species affiliation. Thus, in the face of serological diagnostics taking place in the lab, the most willing helpers in the field were laypersons and potential trainees under Boyden’s dictum and it becomes clear that Boyden began to establish them as amateurs on their own grounds. As a remote teacher he showed and possibly showed off his experience and knowledge, which he suggested he cultivated and developed in previous years, while simultaneously imposing his own formula on the broad public of *Science*. He positioned himself as the expert giving proper advice on complex technologies that were just about to emerge. In doing so, he also pointed to the growing significance of the laboratory against the field, a laboratory to which the Museum was tied, and without which the collection of blood did not make sense.

Bloods as objects: legitimization and gaining support

Scientific practices oriented toward the work in the field, as well as the longstanding cultural traditions of collecting, in which Boyden inscribed himself rather assertively, did not come to a sudden halt after the large-scale field expeditions sponsored by natural history museums went out of fashion (Parry 2004: 12ff., Kohler 2006: 117f.). Rather, they were pursued in variations and gained novel significance in relation to the laboratories focusing on molecular biology. Nonetheless, in the 1940s, animal blood, Boyden’s object of interest, constituted an

unconventional collection for a museum, since samples could not be proudly exhibited. The novel way of Boyden's collecting stood in stark contrast to earlier times, when expeditions returned with heads of lions, skins of great apes, culled elephants or their tusks that were then displayed in natural history museums (Vetter 2008). In Boyden's case, the objects of curiosity did not offer much to see with the naked eye, instead laboratory instruments and the analytical tools produced the visual results.

In the early stage of his endeavour, when Boyden wrote his appeal, the collection of blood and sera was clearly in need of explanation. At the time, it was not self-evident to focus exclusively on the transport and storage of the minute inner components of organic life, highlighted by Boyden's attempts to legitimize his actions in order to gain support and followers. In the official objectives of the Serological Museum, which had been edited in the first issue of the *Bulletin* five years earlier, it was stated that the institution was "dedicated to the principle that the proteins of the blood and of other tissues of the bodies of organisms may be as characteristic of them in health and in disease as are any of their other constituents and are as worthy of preservation and study as their skins and skeletons." (author not specified, Bulletin No 1., 1948, 1). Health and disease had come to symbolise a key reason for field site collection.

When he called for blood samples in *Science* in 1953 the need for justification remained. But, Alan Boyden was not able to ask his readers for animal blood without first paying appropriate homage to the honourable objects of natural history collections whose importance he assured: "Adequate collections of individuals and species of animals are indispensable in the present-day approach to the problems of animal systematics". From there, he then tried to move forward and promote field expeditions guided now by an interest in animal blood: "This requires that much collecting remains for the future and that even some of the territories previously surveyed may need to be revisited" (Boyden 1953: 57). Boyden's rationale for seeking the collection of animal blood – his object of desire – was then explained: it was necessary to "[obtain] the sera of representative animals in order that a thorough study of the amounts of serological and biochemical correspondence of their blood proteins may be made" (ibid.).

The rhetoric to collect animal blood in 1953 followed a dramatic narrative, one that spoke of losses and gains. "[B[loods which would otherwise have been lost may thus be salvaged", Boyden declared firmly. When he was seeking collectors to help him in *Science*, he thus must have felt the need to advertise and legitimize the novel techniques and advantages of blood analysis, announcing, for example, how "sometimes it is possible to identify the species from a spot of blood no larger than a match-head" (1953: 57). Thus, classical taxonomic thinking was turned on its head: instead of morphological and behavioural characteristics dictating species, components in blood were hoped to hold the secrets to diversity.

Boyden postulated that blood analysis would contribute to or even enhance the classification of animals. The premise being, classification would no longer be carried out by mere observation of an animal's morphology and its behaviour. The study of protein correspondence was key to further analyses for example on the etiology of diseases at the time (Kay, 1993, 256). Indeed, Boyden strived for the Museum to become a research centre for biochemical analyses. First, he wrote, "we offer services of several kinds to those interested in comparative serology, such as an identification service for blood dots representing the blood meals of insects or other arthropods feeding upon unknown hosts" (Boyden 1953: 58). And secondly conveying the scientific capacities of this innovative laboratory-museum, "[w[e offer materials, facilities, and instruction to visiting scientists, and publish a semi-annual bulletin, distributed free to those interested in this field of work" (ibid.). Thus, the central organization of a material goods collection was underway. In this way Boyden tried to advance the 'making for granted' of the collected items in order to justify such a thing as the Serological Museum.

Upon careful reading, Boyden's instructions suggest he was somehow torn between conflicting worlds of knowing. On one side, he firmly subscribed to the traditions of systematic zoology and strived to achieve representation. Thus, his call for blood collection demonstrates that he was oriented toward increasing and completing the number of items that would be analysed because comparison and classification relied on as big a variety of samples as possible. Indeed, towards the end of his article, he was sure that "the task of obtaining representative collections of the sera of animals of many groups is so vast that more help will

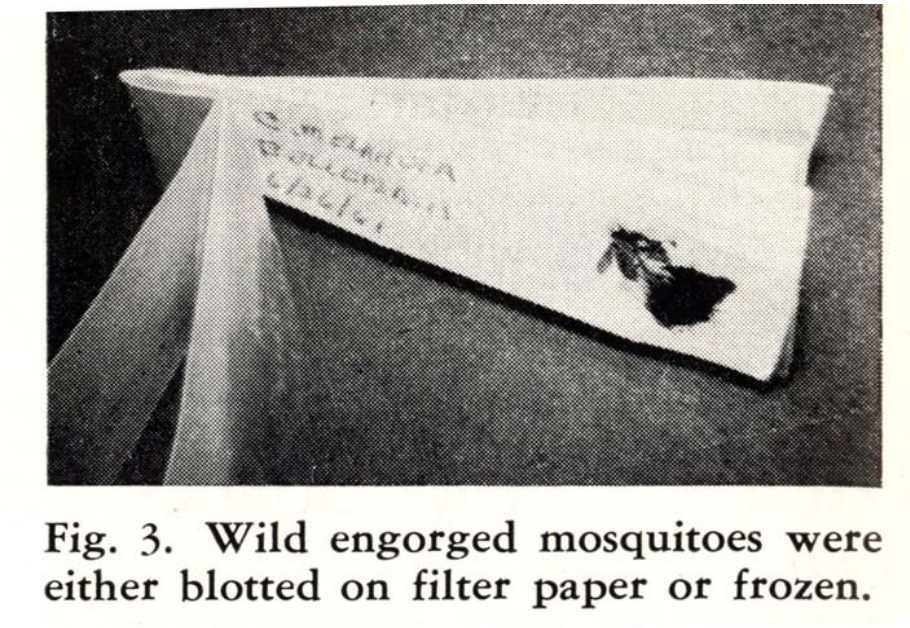


Figure 3. Blotted filter paper

be needed for a long time to come" (Boyden 1953: 58). In order to effectively compare differences and commonalities between different species it was necessary to obtain as complete a collection as possible. But on the other side, Boyden aimed to adopt a chemical approach to taxonomy paralleled by new technologies that promised to improve the classification of scientific objects. It should be kept in mind that collectors were not asked to send their samples to get an analysis done for their own objects. They were kept separate from the investigators, which were asked to call upon the Museum if they needed specific services or materials for their work, or if they wished to receive a sample (A.B., Bull. No. 4, 1950, 1). This way, the Museum would serve as an obligatory point of passage for blood, collectors, investigators and museum staff. The handling of serum samples enabled the Serological Museum to become and serve as the centre of serology.[18]

Collecting as practice: handling and cooking

Another striking peculiarity of Boyden's call for blood samples can be found in the precise information he gave on how to handle the bleeding process and the material that was to be collected. The manner in which Boyden instructed readers to mix ingredients in specific quantities can be understood in terms of Jordan and Lynch's notion of "cookbook knowledge" regarding the application of molecular technologies (Jordan and Lynch, 1998, 779) and especially DNA-extraction.[19] A cookbook consists of simple information that requires accuracy and precision. Cookbook knowledge is usually knowledge that is based on a flow chart or standard procedure. In Boyden's case, and quite typical of cookbooks, the information concerning the contents remains vague, phenomena on a molecular level for example are scarcely explained (ibid. 780). People reading a cookbook are informed about what to begin with and how to proceed, how much to mix in and when to add another substance. After a certain number of trials, users establish a routine, and then the cookbook is only consulted sporadically or becomes obsolete. Boyden did not repeat his call at a later date; hence one can assume that blood-sampling techniques have become more standardized over time.

According to the precision of his instructions, Boyden expected other scientists to know rather little about the process when he addressed them. With respect to the two groups of collectors he discriminated between, he also described two ways of sampling. The first applied

to the group of explorers without facilities for sampling fluid blood, while the second applied to the group of explorers with a certain level of equipment at their disposal. As will become clear, Boyden understood the situations differently.

In the *first* case, he recommended a "simple procedure, for small birds or mammals" (Boyden 1953: 57), during which the collector was to make use of "filter paper or towelling paper to soak up the blood from wounds or the blood and sera from the animal's carcass as it is being skinned." The procedure and the material used were kept simple and the technique seemed to suit the field naturalist that was looking for museum objects (Figure 3). Indeed it followed the precipitation test that George H. F. Nuttall had developed about 50 years earlier.

But Boyden was quite precise and demanding in the amounts of blood he wished to obtain. Thus he asked for "the equivalent of a 2-inch square of soaked filter paper from a single small bird or mammal" (1953: 57). This exigency in amounts may explain why blood taken from the heart has served his demands best, although one could also reason about the potential quality of such blood, and potential preferences by the serologists. If the appropriate quantity was difficult to collect from a single individual, however, Boyden suggested to "repeat it for several individuals of the same species - all on one piece of filter paper if the identification is certain" (ibid.). Thus one paper could be used for several animals of the same species enabling it, in hindsight, to represent a single species. Two things are remarkable about this; first, Boyden seemed to trust the collector's expertise to differentiate between different species; second, this collecting procedure assumed that animals could be classified distinctly to one and the same species according to morphological and behavioural observation. With this instruction to the field-worker he ignored differences within and between species that might be brought to light after closer serological analyses.

How and when the bleeding procedure should occur during the collection process however was not specified for the unaccustomed reader. In this respect the explanations remained imprecise. Nor did Boyden pay attention to the state of the wounded, dying animal or to how the blood would get from the bleeding animal onto the filter paper, although he recommended sampling blood "directly upon cutting open the heart and major vessels" (ibid.). He was not interested in elaborating on the reasons why the skin was taken from the carcasses and he did not ponder over how to take care of the dead creature. Boyden's approach was essentially a truncated version of Latour's descriptions of how things are made flat, as described in *Pandora's Hope* (Latour 1999): the blood was just to be soaked up by the filter paper. For students in the field, this abbreviated advice also allowed them to overlook the visceral process of wounding, hurting or killing a living creature.

But, probably to cover some of these shortcomings, the author offered precise instructions on how to treat the filter paper. They entailed aspects of a sacrifice that may have been deemed a necessary, even a triumphant, part of the transformation from a complete body of the natural world to a tiny, scarcely recognizable tissue sample made flat in order to be analyzed. "The soaked paper should be hung up in the shade to dry at prevailing temperatures, carefully shielded from other papers and from visitations by insects" (ibid.). Interestingly, Boyden described dangers that included naturally occurring enemies and the papers themselves. The threat of contamination was omnipresent. The very process of hanging up and observing serum soaked papers establishes an image of scientific ritual.[20] According to Lynch, such rituals are part of the justification of the "destruction of animals for the 'higher' causes of scientific knowledge and medical progress" (Lynch 1988: 275). Similar to converting the 'profane' object into the 'sacred' in religious rituals, the victim's body is turned into a sacred object (Lynch 1988: 282).

The sacrificial imagery might also have been necessary because the intact animal – its skin and skeleton – would never be exhibited in the Serological Museum and, thus, it was not possible to pay homage to the living creature that it once was. Lynch also speaks of rendering the 'naturalistic animal' into the 'analytic animal' (Lynch 1988: 272). Blood is a sacred substance, imbued with symbolic and religious meaning, and thus one may suggest that the ritual had to do with transforming the animal through its blood donation into an object to be dealt with in scientific processes (Lynch, 1988, 281)[21]. Once transposed onto paper, the blood serum could easily be mobilised and brought or sent – in this case – to the Serological Museum. Here, it could be treated as a precious material that could serve in the systematization of living

organisms. With its technical and spatial infrastructure, it contributed to breaking down the precious material into tiny, hardly visible but analysable components that would become important laboratory objects. Only, the objects were not displayed in this museum – or at the most under the microscope - but subjected to analytic procedures. The Museum served as a reception agency that enabled the translation of the substance's significance.

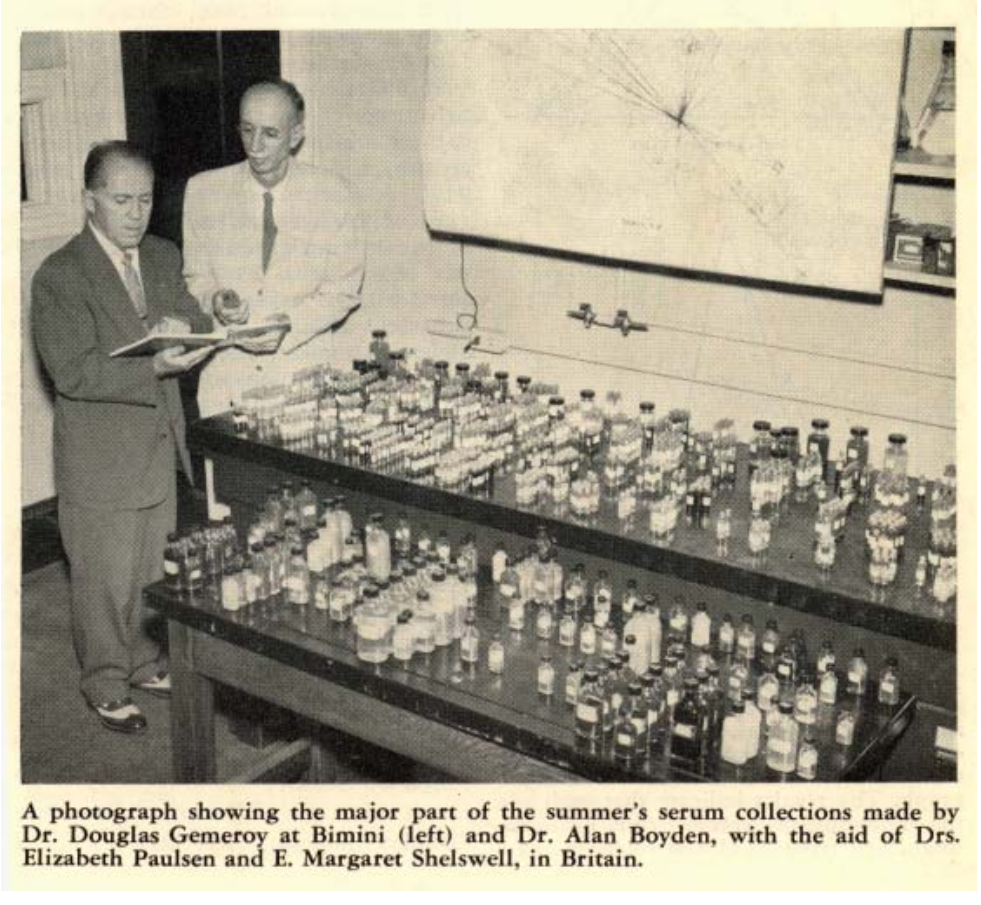
In the end, like any precious letter, the samples were to be posted. This action was described with pragmatics. "Wrap the filter paper in protective paper and keep dry until sent to the Serological Museum" recommended Boyden without mentioning more precautions. The mammal's or small bird's blood was thus stored in a practical, rational way. The paper would not fill huge bags or heavy containers and after it was successfully delivered it could easily be laid out in front of serologists back at Rutgers University, New Jersey. The samples might even be forwarded to other investigators for further analyses by mail.[22]

The *second part* of Boyden's instructions addressed those cases where some preparations had been possible and thus bigger expeditions were taking place. Unlike the first case, the serum was collected in liquid form. Therefore appropriate containers were needed to transport the samples from the field to the Museum, where it was stored or processed in the lab.[23] Hence, Boyden asked for the provision of "containers for fluid blood", "bottles for serum" and "preservatives" (Boyden 1953: 57). Although the choice of container was left to the discretion of the collector, he recommended "any clean jar or container may be used for collecting fluid blood from fresh wounds or cuts" (ibid.). Boyden seemed flexible with respect to the selection of bottles, but he provided the researchers with more information about how to process the blood: "Allow the blood to clot in as cool a place as possible (but whole blood should not be frozen). After it has clotted, loosen the blood from the sides of the container and allow it to stand for several hours at room temperatures or overnight at refrigerator temperatures. During this time the serum will usually express itself from the clot as the clot shrinks" (ibid.).

A fine-tuned temperature-regime in this second case created a demand for certain technical tools while the instructions outlined a complicated system for managing the collected goods. Thus the researchers in the field required various technical objects – for example they would need a refrigerator if they wanted to keep the materials usable. If the researchers were to make sense of the tasks imposed upon them, they would also require certain technical skills. If a refrigerator was lacking, human ingenuity had to replace the tools in order to produce useful material. The serum also required careful handling, and again a strict regime had to be applied, this time in the form of adjusting the amounts of solution: "Pour off the serum as clear as possible into a serum bottle and add the preservative" (Boyden 1953: 57). The preservative was based on standards, consisting off "2% formalin prepared by adding 2 ml of commercial formalin (equivalent to about 40% formaldehyde) to about 98 ml of fresh water. Use one part of this standard 2% formalin to nine parts of serum. The final concentration of formalin in the serum is thus 0.2% and this has served as a very good field preservative" (ibid.). Whether this precise mixture of formalin with water needed to be measured and mixed together in the field or at home was left open to question. Moreover, although a second bottle for the serum was required, Boyden did not specify the kind of bottle this had to be, while obviously the right mixture of the preservative bothered him considerably. (Yet, again he recommended soaking up the serum onto a filter paper if no suitable bottle was available.[24])

Although the simplicity of Boyden's instructions was perspicuous, the kitchen in Boyden's case was not going to be the laboratory, but the field site. Maybe the outdoor collecting site proved to be a suitable place for biological experimenting under certain circumstances, but one can assume that the situation was generally challenging for field collectors: Zoological collectors had been trained to look for gross specimen and visible body parts, which had long been the objects of desire, and blood had proven difficult to preserve. Boyden however employed his powers of persuasion to introduce the technicalities of handling liquids, managing bottles and dealing with temperature regimes for many kinds of animals. This may help explain why he tried to rely on simplicity and robust procedures. The two ways of collecting blood he differentiated between however created a point of tension. On the one hand, the filter paper technique that seemed so simple was a kind of revolution over the more traditional mores of naturalists. The liquid sampling technique, on the other hand, demanded specific skills from those interested in zoological expeditions.

In theory, if all field collections were made according to Boyden's instructions, samples donated to the Serological Museum would be comparable and the serological analyses that followed would be systematic and scientifically sound. Therefore, as in the cases of defining specific helpers and choosing relevant research objects, when Boyden characterized collecting practices he was not merely instructing interested zoologists. Since he inscribed his 'cookbook' in a *Science* article, the collection and handling of blood could – from that point forward – be regarded as standard procedure and he was the author of the 'recipe'. In this fashion, he aimed to establish his authority concerning serum sampling and production in the field, which could then be consulted for advice. The Museum meanwhile served as a kind of significance converter, relying on its collection to guide the development of lab procedures and standardized treatments of animal blood.



A photograph showing the major part of the summer's serum collections made by Dr. Douglas Gemeroy at Bimini (left) and Dr. Alan Boyden, with the aid of Drs. Elizabeth Paulsen and E. Margaret Shelswell, in Britain.

Figure 4. The summer serum collection with Dr. Douglas Gemeroy and Dr. Alan Boyden of the Serological Museum.

Becoming the centre of a network: a museum as a mediator between the field and the lab

Boyden urgently needed tangible enrolment numbers (Callon:1999, 71f.) in order to achieve his goal of establishing a world centre of serology with a representative collection of animal sera.[25] In one of the last paragraphs of his article, thus, Boyden asked future explorers to inform him of their plans. If they would contact him before they left for the field he could provide them with the appropriate tools for the task. Consequently, the Museum would be able to act as a kind of

intermediary, justifying the serologists' needs. However, Boyden did not limit himself by addressing only one group. As we have seen, he did not want to leave behind the field of traditional collectors for the serological enterprise, but he was also seeking the enrolment of other researchers in the expanding field of the biological sciences.

What was Boyden able and willing to 'give' in return for the help of others? The helpers, he assured, would get credit and thus be rewarded. Latour and Woolgar refer to credit as a "commodity, which could be exchanged" (Latour and Woolgar 1986: 192). Boyden indeed promised to acknowledge "the source of all contributions of animal sera". The name of the collector was not going to be inscribed on the specimen – as was the case in naming exemplary specimens following Linnéan nomenclature in natural history collections. But the blood sample had, according to Boyden's narrative, to be labelled accurately, like any collected item in the field and he gave instructions on how to do so. Thus, the finder should be "writing in pencil, directly on the paper, the scientific name of the specimen, date, locality, whether sample is pooled or single, and *name of the collector*" (emphasis added, Boyden 1953: 57).[26] A record sheet back at the Museum documented every sample and included a box to fill in the collector's name (beside species and common name also the institution, the description as well as the history and the notes of the analysis).[27] As for the name of the finder, the labelling process seemed to follow traditional collecting methods. It aimed to completely satisfy the necessary standards, which meant the objects could be fitted into a scientific collection, the knowledge about its existence would be recorded in a file and its original collector could be traced. Despite these previsions, as soon as the serum was subjected to laboratory procedures, it eventually lost the authorship of the finder and merged into laboratory data and scientific text.

Although the Museum, with its *Bulletin*, occasionally distributed credit in its first years by mentioning the sources from which the samples came,[28] in the scientific papers that drew on tissues from the Museum of Serology, no such detailed references can be found. But what generally happened is that the credit they distributed went to the Museum.[29] Alas, the concept of the cycle was reversed when credit was re-directed and re-distributed to the Museum itself. This meant that by the time the items were sent on to other researchers for further interpretation, the amounts of blood serum had been incorporated by the collection as a whole – and the cycle of exchange had been interrupted. This observation is affirmed by a diagram that was published in Bulletin No. 4. The "individual collectors" were set in opposition to the "individual investigators" (Figure 4). While the donators represented institutions, the investigators were working in serology, protein chemistry, immunology or genetics & evolution (A.B., Bulletin No. 4, May 1950, 1) and published in these scientific fields. The Museum itself was situated directly in the middle. According to this scheme, it functioned as a node in a network of exchange.

Conclusions

The *Serological Museum Bulletin* characterised the academic year 1954/1955 – i.e. the year following Alan Boyden's call for collecting support in *Science* – as one of the most successful and fertile years in the history of the Museum. The trophies that had been collected were displayed in a photograph in the *Bulletin*. However, it became clear from the article that it had been mainly staff and established collaborators of the Museum who were responsible for the collecting (Boyden 1955: 8). Spontaneous donations from all over the world were not mentioned. The call in *Science* thus was turned into reality by the Serological Museum itself.

Despite this somehow disappointing outcome for the Museum, Boyden's instructions on collecting blood on field sites provided a kind of 'window of opportunity' to track some of the ways in which actors, objects, practices and centres of networks were thought to generate novel insight into the biological sciences and the corresponding collections. A final look at each of these aspects will reinforce the argument presented in this paper. Namely, the Museum, and perhaps similar tissue repositories, point to some of the changes in the biological sciences that were underway at the time. As a scientific endeavour the Serological Museum served as a kind of significance converter between the field and the laboratory.

Firstly, it was a question of numbers. When Boyden published his call for blood collection in *Science*, he was keen to increase the quantity, not only of samples but also of collectors, in order to increase the significance of his collection at the Serological Museum. Thus his paper was ambiguous in relation to whom it addressed. The analysis showed that, amongst the

helpers he was avidly looking for, Boyden addressed classical naturalists, interested in skins and skeletons. But in his account a second kind of collector emerged, individuals who were familiar with more complex methods and technologies: microbiologists, biochemists and pharmacologists. In addition to the traditional naturalists, the quasi experts, equipped with the right tools for the job, were no less in need of education, which Boyden was willing to provide. It also became clear that both of the groups were seen as instrumental in relation to the Museum that depended on the materials they were sending.

Secondly, the classification of animals and plants by analysing a single spot of blood was new to the world of biology in the 1950s, and thus took some explanation on the part of Boyden. Even more challenging was the task of convincing the scientific public of the need for an institution that would represent the animal kingdom by merely sampling blood. In order to establish the 'making for granted' of such an unstable entity as a spot of blood, it required clarifying that such a collection would provide the analytic terrain for the use of these materials. The persuasive notion of "salvaging blood" was used to legitimise the serological endeavour for scientific preservation and study. In what can be read as a desperate act revolting against the decrease of zoological collecting, Boyden called to revisit former collecting territories under novel auspices. New kinds of blood analysis services and the provision of facilities and materials – so he argued – should make this undertaking worthwhile.

Boyden *thirdly* described two ways of collecting, once again proving to be torn between traditional habits and scientific progress. His directions, in both cases, reflected a 'cookbook' style. The accuracy and simplicity of the descriptions turned complex actions into self-evident ones. The first set of instructions concerned issues pertaining to classical sampling. Striking, in this instance, were the ritualistic overtones that were introduced to transform the cruel act of blood sampling into a scientific action that rendered animal blood an analytic entity. The second set of instructions described the use of glass containers that had gained prominence during the War. This way of collecting followed a more refined temperature and quantity regime that later became typical of molecular biology techniques.

Fourthly and finally, in an effort to establish a kind of give-and-take relationship, credit was promised to those contributing to the collection. At the same time, however, it was not made explicit that it would be the Museum profiting in the first place from the samples that others sent. Ironically, the "reception agencies", and thus scientists from any institution that published work based on these samples, thanked the Museum for helping them with the materials it housed in its cold rooms. This not only meant that the collectors' authority was completely lost, but it also signified that the investigators were able to benefit from the donations of others. With this act, the Serological Museum saw and finally established itself as the definite centre of a network, a sine qua in respect to biological materials collections.

Thus, although not much can be said about how successful Boyden was in his appeal, the analysis revealed a prospective account concerning some decisive characteristics systematic serology had to deal with during a crucial research period. These entailed: the multiplication of researchers' roles in the field who were confronted with harvesting blood from living or dead animal bodies; the creation and qualification of new collecting objects; collecting techniques that relied on new laboratory regimes for handling materials; and the transformation of the collecting institution into a scientific network that handled a novel variety of bio-molecular objects.

Boyden acted as the proud head of the Serological Museum that was in reality more or less a mere collection of animal sera and antigens stored in a cold room of a biology department at a state university. As a symbol, the Museum represented many of the characteristics that came to define biochemical and molecular work during the mid to late twentieth century. The value of preserved blood for systematic comparison in serology and other analyses required new means of collection, transport and storage to be introduced. If we consider these developments in relation to today's emphasis on bio-molecular techniques and biomedical practices, it may help explain how proteins, genes and other substances that are found in blood, as well as blood itself, have become such meaningful objects of study. Furthermore, Boyden's narrative contributes to the demarcation of the Museum from the collecting territory, the field location, establishing a serological collection as a valuable site of laboratory analysis.

Under the header "This Museum Banks on Blood" a local New Jersey newspaper

celebrated the achievements of the institution almost twenty years after Alan Boyden's call. The clip pointing out some of the achievements of the collection was one of the last traces that documented the fate of the Serological Museum.[30] The final issue of *The Bulletin* was published at the end of 1974. A laconic email from a biologist at Rutgers University gave some further evidence of what happened to the blood samples. "As far as the Serological Museum concerns: That is long gone. The refrigerator containing all of the samples was in my 'new' laboratory when I moved from Douglass in 1984. Someone had unplugged it and when I opened it the smell was awful, all of the bloods had deteriorated and were thrown away. There are no records that I have found other than one or two news articles in a Rutgers Bulletin" (Email correspondence Chuck Martin, June 17, 2008).

This account has shown how the foci on research subjects (the field zoologists) and scientific objects (blood from living or dead animals), practices (sampling on filter papers or in jars) as well as networks (of credit), were re-aligned in order to advance comparative analysis in serology in the mid 1950s. In this light, the Serological Museum can be understood as a significance converter that served to shape collecting procedures according to the needs of the emerging biomedical research. It had become an important point of passage, serving the necessity to assemble samples of animals in order to make them comparable before they could be analyzed in the high-tech laboratory.

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Notes

1 For early laboratory studies by scholars in science, technology and society studies see also Latour and Woolgar (1979), Latour (1987), Knorr-Cetina (1991).

2 The revolutionary potential brought about by molecular biology needs careful consideration, but it was undoubtedly a hot topic toward the end of the 1970s and the early 1980s. Jordan and Lynch refer to the molecular biological 'revolution' as a fundamental change in the focus and practice of biology (Jordan and Lynch, 1993, 165p.). Jordan and Lynch (1993, 166) Burian (1991) and Kay (1993) propose that the revolution resulted from the introduction of a range of diverse techniques rather than a change of core theoretical approaches.

3 The existing literature is cautious about suggesting that this emerging field is undergoing a revolution, but it nevertheless focuses on institutional and personal reconfigurations as well as changing epistemic approaches (Chadarevian and Strasser, 2002, Kay, 1993, Kevles and Geison, 1995, Abir-Am, 1997).

4 See also the ‚Taxonomy at the Crossroads' project, Department of Sociology, Lancaster University, http://www.lancs.ac.uk/fass/projects/taxonomy/, accessed 22.7.2010.

5 The *Bureau of Biological Research* was founded in 1936 and was one of the oldest research organizations in the life sciences at Rutgers University. Boyden was elected Chairman at the time of its foundation (http://lifesci.rutgers.edu/history/bureau_of_biological_research.htm, accessed 8.10.2008).

6 Systematic Serology traces back to the works of G. H. F. Nuttall at Cambridge University, but also had a history of nearly a quarter of a century at Rutgers University before the Museum was founded (Bull. No. 7, Nov. 1951). Nuttall was an important specialist in immunology and blood chemistry in the first half of the 20th century and he became a leading figure in the analytic methods Boyden built upon (Bulletin 11, Nov. 1953, p. 7).

7 RUA: Greif, Samuel (1949), Serological Museum Completes First Year at University Here, Sunday Times.

8 See footnote 3.

[9] RUA: Rutgers News Service, George H. Holsten, Jr., Director, April 6-7, presumably 1951.

[10] RUA: Finley, Charles Q. " 'Blood museum' calls its founder back from farm", newspaper clipping.

[11] RUA: Finley, Charles Q. " 'Blood museum' calls its founder back from farm", newspaper clipping.

[12] Boyden managed to obtain a share of the remaining sera of Nuttall's collection in 1950. See.

[13] Rutgers University Archives, Faculty Collection, Alan Boyden – Biographical File (RUA): Finley, Charles Q. " 'Blood museum' calls its founder back from farm", newspaper clipping.

[14] The genetic analyses conducted by the serological community contributed to the transformation of the "kingdoms of living things" (Blackwelder 1964: 74) and therefore to critical re-classifications in systematic zoology and a reordering of the biological sciences.

[15] Boyden edited the *Serological Museum Bulletin* from 1948 until the 1970s. Although the journal was never officially cancelled, the last issue was printed and distributed in 1974. In the rest of the paper it will be referred to simply as *Bulletin*.

[16] Similarly, Rheinberger describes two decisive shifts punctuating the history of biology: The molecular biological shift and the gene technological shift (Rheinberger, 2008).

[17] "The classification of the animals" was, in fact, the title of a session that was organised during the symposium, "Operation Knowledge", of the AAAS in 1952, at which Boyden delivered a speech (*Science*, Vol. 115, No. 2981, p. 185).

[18] A short abstract of a communication presented by Fleck refers to the "reification of states and processes, and even of laboratory operations" that characterised serology after "the breakdwon of the old theory of immunity" (Fleck 1988: 343).

[19] Jordan and Lynch draw on a concept that was originally developed by Schutz. They use it in the context of a study about the design of PCR – a technique in molecular biology developed in the early 1980s. They observed that descriptions of such techniques often resemble recipes, giving exact information about ingredients and quantities of needed product (Jordan and Lynch, 1998, 779). Such recipes refer to "items of equipment, volumes of ingredients, temperature settings and numbers of cycles" (ibid.).

[20] Michael Lynch describes the transformation of – in his case - a living rat "through a series of mechanized and methodical actions into the cultural object, 'data'" (Lynch, 1988, 272).

[21] To be precise: Lynch himself speaks of analytic subjects. The transformation process – according to Lynch – illustrates further: "…that the death of the animal is what makes possible its analytic value, that this death becomes a vehicle of human identification, and that it is accomplished through a ritual enactment" (Lynch 1988: 282).

[22] These guidelines already seem to hint toward the digitization of information undergone in the 1990s and today, where genetic and biochemical materials are to "be rendered…in artifactual forms", while they are "used independently of the organism in which they originally existed" (Parry, 2004, 148).

[23] A kind of iconic container or box (known as a 'dry-shipper') designed to cryopreserve specimens and tissues collected during fieldwork (Parry, 2004, 139). Bronwyn Parry recounts, that "Portable, hand-held cryogenic storage flasks, or 'dry shippers' as they are known, which were first used industrially in the United States to transport bull semen in the

1950s, were introduced into natural-products research in the early 1990s and are now routinely employed by field collectors in any circumstance where maintaining enzymic activity or molecular integrity is paramount" (Parry 2004: 139).

[24] An article, by the author's scientific peers, described how they went about collecting blood from crocodilians, talking curators, after some "soul searching", into allowing them to bleed precious, endangered crocodilians in their care (Dessauer, 2002, 306). From this example, it is obvious that filter paper is much more convenient to mobilize than transporting a whole crocodile home in order to study it!

[25] "To interest other actors is to build devices which can be placed between them and all other entities who want to define their identities otherwise", writes Callon, specifying the concept of enrolment (1999, 71f).

[26] Interestingly, the number of species represented was listed and the amount available counted when the present status of the Museum was published in 1950 (author not specified, Bulletin No. 5, October 1950, 1).

[27] Such a form was printed for explanatory and illustrative reasons at the very beginning of the Museum in the *Bulletin* (author not specified, Bulletin No. 2, 1949, 8).

[28] E.g. A.B. (presumably Alan Boyden), Bulletin No. 4, May 1950, 4; Pryor, in. Bulletin No. 8, May 1952, 3.

[29] In the "Starch Gel Electrophoresis of Some Invertebrate Sera", for which the collection provided a sample (Science, New Series, Vol. 127, No. 3297, Mar. 7, 1958, pp. 519-520), the authors Kenneth Woods and others refer to the Museum in footnote 5. Elias Cohen – specialised in the study of serum proteins in reptiles – thanked the Serological Museum for contributing serum antigens and financing shipment of materials (Cohen, 1955, 394).

[30] RUA: Rutgers News Service, Joseph O'Rourke, manuscript, 26.2.1971.

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Notes

[1] For early laboratory studies by scholars in science, technology and society studies see also Latour and Woolgar (1979), Latour (1987), Knorr-Cetina (1991).

[2] The revolutionary potential brought about by molecular biology needs careful consideration, but it was undoubtedly a hot topic toward the end of the 1970s and the early 1980s. Jordan and Lynch refer to the molecular biological 'revolution' as a fundamental change in the focus and practice of biology (Jordan and Lynch, 1993, 165p.). Jordan and Lynch (1993, 166) Burian (1991) and Kay (1993) propose that the revolution resulted from the introduction of a range of diverse techniques rather than a change of core theoretical approaches.

[3] The existing literature is cautious about suggesting that this emerging field is undergoing a revolution, but it nevertheless focuses on institutional and personal reconfigurations as well as changing epistemic approaches (Chadarevian and Strasser, 2002, Kay, 1993, Kevles and Geison, 1995, Abir-Am, 1997).

[4] See also the ‚Taxonomy at the Crossroads' project, Department of Sociology, Lancaster University, http://www.lancs.ac.uk/fass/projects/taxonomy/, accessed 22.7.2010.

[5] The *Bureau of Biological Research* was founded in 1936 and was one of the oldest research organizations in the life sciences at Rutgers University. Boyden was elected Chairman at the time of its foundation (http://lifesci.rutgers.edu/history/bureau_of_biological_research.htm, accessed 8.10.2008).

[6] Systematic Serology traces back to the works of G. H. F. Nuttall at Cambridge University, but also had a history of nearly a quarter of a century at Rutgers University before the Museum was founded (Bull. No. 7, Nov. 1951). Nuttall was an important specialist in immunology and blood chemistry in the first half of the 20th century and he became a leading figure in the analytic methods Boyden built upon (Bulletin 11, Nov. 1953, p. 7).

[7] RUA: Greif, Samuel (1949), Serological Museum Completes First Year at University Here, Sunday Times.

[8] See footnote 3.

[9] RUA: Rutgers News Service, George H. Holsten, Jr., Director, April 6-7, presumably 1951.

[10] RUA: Finley, Charles Q. " 'Blood museum' calls its founder back from farm", newspaper clipping.

[11] RUA: Finley, Charles Q. " 'Blood museum' calls its founder back from farm", newspaper clipping.

[12] Boyden managed to obtain a share of the remaining sera of Nuttall's collection in 1950. See.

[13] Rutgers University Archives, Faculty Collection, Alan Boyden – Biographical File (RUA): Finley, Charles Q. " 'Blood museum' calls its founder back from farm", newspaper clipping.

[14] The genetic analyses conducted by the serological community contributed to the transformation of the "kingdoms of living things" (Blackwelder, 1964, 74) and therefore to critical re-classifications in systematic zoology and a reordering of the biological sciences.

[15] Boyden edited the *Serological Museum Bulletin* from 1948 until the 1970s. Although the journal was never officially cancelled, the last issue was printed and distributed in 1974. In the rest of the paper it will be referred to simply as *Bulletin*.

[16] Similarly, Rheinberger describes two decisive shifts punctuating the history of biology: The molecular biological shift and the gene technological shift (Rheinberger, 2008).

[17] "The classification of the animals" was, in fact, the title of a session that was organised during the symposium, "Operation Knowledge", of the AAAS in 1952, at which Boyden delivered a speech (Science, Vol. 115, No. 2981, p. 185).

[18] A short abstract of a communication presented by Fleck refers to the "reification of states and processes, and even of laboratory operations" that characterised serology after "the breakdwon of the old theory of immunity" (Fleck, 1988, 343).

[19] Jordan and Lynch draw on a concept that was originally developed by Schutz. They use it in the context of a study about the design of PCR – a technique in molecular biology developed in the early 1980s. They observed that descriptions of such techniques often resemble recipes, giving exact information about ingredients and quantities of needed product (Jordan and Lynch, 1998, 779). Such recipes refer to "items of equipment, volumes of ingredients, temperature settings and numbers of cycles" (ibid.).

[20] Michael Lynch describes the transformation of – in his case - a living rat "through a series of mechanized and methodical actions into the cultural object, 'data'" (Lynch, 1988, 272).

[21] To be precise: Lynch himself speaks of analytic subjects. The transformation process – according to Lynch – illustrates further: "…that the death of the animal is what makes possible its analytic value, that this death becomes a vehicle of human identification, and that it is accomplished through a ritual enactment" (Lynch, 1988, 282).

[22] These guidelines already seem to hint toward the digitization of information undergone in the 1990s and today, where genetic and biochemical materials are to "be rendered…in artifactual forms", while they are "used independently of the organism in which they originally existed" (Parry, 2004, 148).

[23] A kind of iconic container or box (known as a 'dry-shipper') designed to cryopreserve specimens and tissues collected during fieldwork (Parry, 2004, 139). Bronwyn Parry recounts, that "Portable, hand-held cryogenic storage flasks, or 'dry shippers' as they are known, which were first used industrially in the United States to transport bull semen in the 1950s, were introduced into natural-products research in the early 1990s and are now routinely employed by field collectors in any circumstance where maintaining enzymic activity or molecular integrity is paramount" (Parry, 2004, 139).

[24] An article, by the author's scientific peers, described how they went about collecting blood from crocodilians, talking curators, after some "soul searching", into allowing them to bleed precious, endangered crocodilians in their care (Dessauer, 2002, 306). From this example, it is obvious that filter paper is much more convenient to mobilize than transporting a whole crocodile home in order to study it!

[25] "To interest other actors is to build devices which can be placed between them and all other entities who want to define their identities otherwise", writes Callon, specifying the concept of enrolment (1999, 71f).

[26] Interestingly, the number of species represented was listed and the amount available counted when the present status of the Museum was published in 1950 (author not specified, Bulletin No. 5, October 1950, 1).

[27] Such a form was printed for explanatory and illustrative reasons at the very beginning of the Museum in the *Bulletin* (author not specified, Bulletin No. 2, 1949, 8).

[28] E.g. A.B. (presumably Alan Boyden), Bulletin No. 4, May 1950, 4; Pryor, in. Bulletin No. 8, May 1952, 3.

[29] In the "Starch Gel Electrophoresis of Some Invertebrate Sera", for which the collection provided a sample (Science, New Series, Vol. 127, No. 3297, Mar. 7, 1958, pp. 519-520), the authors Kenneth Woods and others refer to the Museum in footnote 5. Elias Cohen – specialised in the study of serum proteins in reptiles – thanked the Serological Museum for contributing serum antigens and financing shipment of materials (Cohen, 1955, 394).

[30] RUA: Rutgers News Service, Joseph O'Rourke, manuscript, 26.2.1971.

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