You and Your Body
Investigating Biological Form and Function

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Introduction

Veterinary students are typically intelligent, enthusiastic and driven yet these seemingly desirable personality traits can sometimes lead to a rigidity of approach and a fixation on examination performance. New approaches to teaching are needed to engage students early on in their careers, promoting a more holistic understanding of biological systems, automatically integrating basic and clinical sciences.

The study of form and function (anatomy) has fascinated artists and scientists for centuries. In spite of this and in spite of recent advances in biological imaging, human and veterinary anatomy classes are restricted to cadaveric dissection of fixed material (humans **or** animals respectively). As humans, we tend to have a healthy interest in our own bodies and thus human anatomists are easily engaged in the subject area, relatively early on. Veterinary classes however mainly focus on equine and canine anatomy which is completely new to students and thus less easily related to their existing (A' level) knowledge base.

In this project, we have harnessed the natural egotism of students, getting them engaged in biological form and function through investigation of their own bodies and relating this new information to the animals that they meet later in the course.

Primary aims and objectives:

Aim: To introduce students to key concepts in animal design through investigation of their own bodies using novel visualization and quantification technologies.
Objectives: Students undertake a practical class comprising set tasks which are closely related to concepts introduced in lectures such as musculoskeletal form and function, physical adaptation, evolution (hominisation), bi/quadrupedal locomotion and foot function.

The material will be delivered as a practical session in the first week of the new curriculum in October 2007 (BVM 1). Students learn about animal form and function with lectures focusing on size and scaling, mammalian and human evolution and design principles in locomotion. The **YOU AND YOUR BODY** practical class pulls together all of the themes covered in the first week of teaching, encouraging students to approach the design of their own bodies with open and inquisitive minds and, at the same time, appreciating that they are constructed from the same anatomical blueprint as the animals they encountered in their coming academic and clinical years.

Methodology Students will investigate body form and function using both simple and highly technical methods for its description and quantification. Six (30 minute) stations will be set up in various teaching rooms (DR, Museum, teaching labs), each with a set task. Four students will be allocated per station - stations will be repeated (5x) to accommodate 120 students per session. Students will follow the instructions given noting their key findings. Each station will contain a detailed paragraph describing the theoretical background to the concept/technique and a step by step guide to completing the task. Further resources will be given on colourful info-cards and on the VLE. Full details of stations can be found below.

Benefits to Learning and Teaching in the College:

- **You and Your Body** introduces key concepts in animal design and thus is relevant to students on all courses. For example, the hominisation station is relevant to GATEWAY students during their Evolution module, whereas the somatotyping station would be relevant to discussion of obesity in their comparative reproduction module.
- The skeletal material resides in the Anatomy museum when not required for teaching
- The ultrasound machine is ring-fenced for anatomy teaching at Camden.
- The stations are highly visual and hands-on and are perfect for engaging potential applicants at RVC open day events and Road shows.

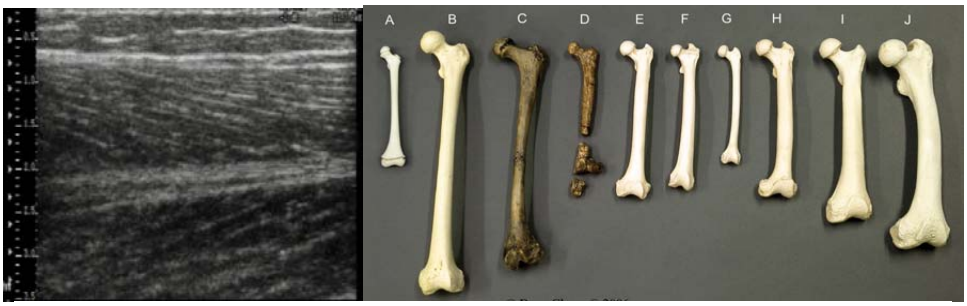
Summary

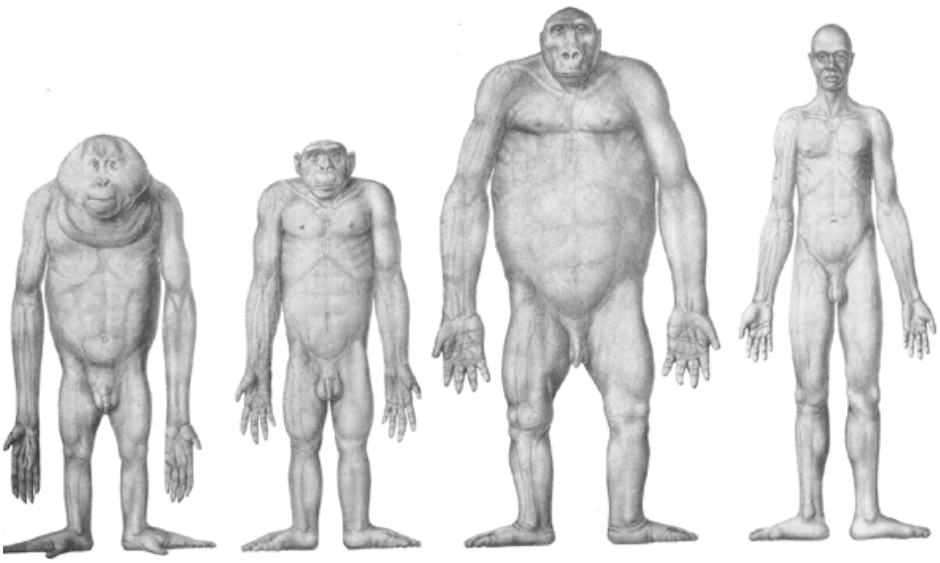
The session was successfully delivered in October 2007. It took a large amount of planning to run 240 students through the stations and thus the number of stations was reduced. Small group sizes encouraged team work and were non-threatening. Students were observed teaching each other, sharing existing knowledge and experiences. The ultrasound machine was particularly popular as were the MRI scans which really got them thinking about skeletal tissues. Students were not keen to remove their shoes for the pressure station and thus group participation was poor. The stations could be further developed for coming years by increasing the amount of clinical relevance.

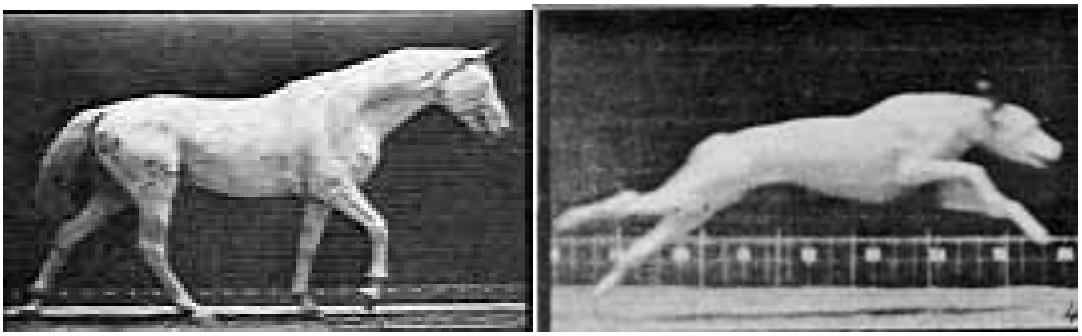
Future

You and Your Body was also used in Spring 2008 for a visit of 100 local school children.

How Bodies Work:
Investigating Form and Function in Humans and Other Animals







Name:
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ANTHROPOMETRY is the measurement of body form and is widely used to examine differences within and between species, explore evolutionary trends and inform clinical diagnosis and treatment.

In this practical class you will explore body form and function using common methods for its description and quantification. A series of 4 stations have been set up in the dissecting rooms and anatomy museum, each with a set task. You will work in groups of six (your DL groups). Follow the instructions given noting down your key findings. Each station will contain a detailed paragraph describing the theoretical background to the technique and a step by step guide to completing the task. Further reading will also be given along with pointers to accessing additional information. **You have 30 minutes to complete each station and 5 minutes to transfer between stations.**

Learning Outcomes
By the end of this practical class you should be able to:

(1) List common methods for visualising anatomy and appreciate which modality is most useful for bone/muscle/tendon/cartilage
(2) Locate the major hind and forelimb muscle groups in a biped and quadruped and appreciate that differences in limb anatomy are directly related to locomotion.
(3) Describe the major differences in foot structure and function in humans, chimps, horses and dogs.
(4) Describe the main ways in which human skeletal proportions differ from those of other living and fossil great apes.

(1) Inside Information

Humans have been investigating and describing anatomy for many thousands of years. This is because FORM and FUNCTION are intimately linked, giving us important clues as to how our bodies work. The simplest way to look at internal structures is to dissect fresh or fixed cadavers, removing the skin and uncovering the structures hidden within. Recent advances in imaging have allowed us to look inside LIVING BODIES, both at rest and when performing set activities. Imaging is particularly useful for looking at diseased or damaged tissues and charting the healing process. Imaging is however often expensive and time consuming and thus fixed and fresh cadaver dissection is still commonly used, particularly in helping students of human and veterinary medicine learn basic anatomy.

Aims: To appreciate the different methods available for looking at body tissues and how each modality is biased towards a particular structure(s)/tissue type.

Equipment: Fresh and fixed forelimb, forelimb skeleton, X-Ray, MRI and CT image of forelimb, ultrasound machine.

Protocol: Triceps and biceps brachii are important muscles in forelimb stability and mobility. Locate both of these muscles along with the humerus/radius/ulna and elbow joint in each of the specimens provided. Use the ultrasound machine to locate these same structures in a team member. Note how the different musculoskeletal structures visualised differ in each specimen/imaging modality (Table 1).

I want to read more about this: There are a wide range of anatomy text books in the library. Browse through a selection – some will be better for dissected material, others for radiography. There is an extensive radiography collection in the Hawkshead library. You can also access the RVC radiographic database online.

Where else can I look? The Royal College of Surgeons of England website (http://www.rcseng.ac.uk) has information on the Hunterian Museum (Holburn) and Wellcome museum of Anatomy and Pathology (Euston Road). The Hunterian Museum has a virtual tour online and hosts free guided tours every Wednesday at 1pm (http://www.rcseng.ac.uk/museums/information, to book call 020 7869 6560). The Wellcome Museum is open 10-5pm Monday to Friday. For more information, or to book a group visit, please contact by telephone on 020 7869 6560 or email museums@rcseng.ac.uk. The Science museum health matters exhibit for history of radiology (www.sciencemuseum.org.uk).

(2) We ain't nothing but mammals

Most people can name at least a few of their own limb muscles/muscle groups. However, you might be surprised to learn that most mammals have exactly the same muscles as you. It is sometimes hard to work out where they all are – this is because domestic animals move on all four limbs (i.e. they are quadrupedal) and thus everything is oriented differently. They can also be a very different size and shape – again because of differences in locomotion.

Aims: to introduce you to key muscle groups of the limbs and their location in bipeds and quadrupeds.

Equipment: 1 horse, 2 cows and 2 greyhounds, white labels.

Protocol: Use the sticky labels provided and attach them to your subjects clothing overlying the following muscle groups:

Forelimb: triceps, biceps, wrist and finger flexors, wrist and finger extensors, pectorals (pecs), latissimus dorsi (lats).

Hindlimb: gluteals (gluts/rump), quadriceps, hamstrings, ankle dorsiflexors (pull toes up), ankle plantarflexors (point toes down).

Your subject should now adopt a quadrupedal (on all fours) posture. Work out where the SAME MUSCLES are on the LIVE. Draw and outline of your body and that of the animal you are working with. Annotate your diagrams with muscle groups (Figure 1). List 5 ways in which human and horse (dog/cow) locomotor anatomy is different, and five ways in which it is the same. What are the biggest differences in limb design between you and the live animal? Can you link each of these structural differences to locomotor function?

I want to read more about this: For horse, dog and cow see various veterinary anatomy text books in library. For human anatomy see Aiello and Dean (2002) An introduction to human evolutionary anatomy. QM23.2 AIE.

Where else can I look? Hunterian and Wellcome museums as above, RVC Anatomy Museum Camden, Science museum veterinary history exhibit (www.sciencemuseum.org.uk for information). The Bodies exhibition website (http://www.bodiestheexhibition.com/bodies.html) has a section on the history of anatomy and an education section where you can learn about the key human body systems.

(3) Step by Step

When you walk, you exert a force on the ground equal to gravity (~10m/s^2) multiplied by your body mass The ground then exerts a force of equal magnitude and opposite direction back on your foot – **GROUND REACTION FORCE (GRF)**. This force helps support you and prevents you from collapsing in a heap when you stand up. In a 65kg person GRF = 65 x 10 = 650N. Biomechanists measure this force as its trace (graph) is typical to both the animal and style of locomotion being used. If we know what the typical force trace should look like, we can tell if and why something is going wrong.

Pressure plates are a simple way of measuring ground reaction forces. They give information on how force is distributed across the sole of your foot when walking. They are a very useful clinical tool for visualising problems in foot function as they help us identify areas of abnormally high pressure (which can lead to ulcers and eventually amputations in human diabetics). They also give us information as to the path of force across the foot. In humans, this should start under the heel pad, move laterally along the sole of the foot to the base of the toes and then cross from the base of the little toe to the base of the big toe and off. This pattern of force application is an important sign of healthy foot function.

Aims: To appreciate the relationship between foot structure and function in different animals. To observe the difference in underfoot pressure in walking and running in humans.

Protocol: (1) Choose a subject to walk over the plate making sure that you get a whole-foot contact. Note down your peak loading forces (N), loading rate (Ns) and stance time (s). How does your centre of pressure line move from heel to toe? Do you have a straight line (unhealthy stiff foot/weak arches) or is there pronation from little toe to big (healthy)? Do you have any areas of high pressure? These may be related to previous knee or ankle injury. Do the same protocol for running. Fill in Figure 2A. (2) How does a human pressure record differ from the animal examples you have been provided with (see Figure 2B below)? How might these differences relate to the way that they walk?

I want to read more about this:

There are lots of basic biomechanics texts in the library at Camden and Hawkshead: Nigg BM (1999) Biomechanics of the musculo-skeletal system QP301 NIG. Biewener A.A. (1992). Biomechanics - structures and systems a practical approach QP303 BIO. Rooney J R. (1969) Biomechanics of lameness in horses SF959.L25 ROO. Nigg, BM. (2000) Biomechanics and biology of movement QP301 NIG. Hamill J (2003) Biomechanical basis of human movement QP303 HAM. Nordin M (2005) Basic biomechanics of the musculoskeletal system QP303 BAS.

Where else can I look? See www.rsscan.com for journal articles on pressure records in humans, horses and cows. Some sports shoe stores have pressure plates that you can use before you buy your trainers – why do you think this is (http://www.runnersworld.ltd.uk/shoefinder.htm)?

(4) Aping Around

Humans split from their closest living ancestors, the chimpanzees, between 5 and 13 million years ago. **HOMINISATION** is the process by which ape-like features are replaced by the human-like features that are universally recognised today. We can measure aspects of hominisation by measuring aspects of the bony skeleton. Relative bone lengths give us clues as to the primary locomotor mode of that animal.

Aims: Describe the main ways in which human skeletal proportions differ from those of other living and fossil great apes.

Equipment per station: Chimpanzee and Fossil skeleton, tape measures, dental wax

Protocol: Measure the hominisation indices as described in Table 3. Are you closer to an orang-utan, chimpanzee or Australopithecine? What clues does this give us as to locomotion, feeding and environment?

Supra-orbital Height Index (frontal brain size)

Apes <50, Australopithecus Africanus ~61, Homo erectus: 63-67, High values = good co-ordination and memory

Basic Mandibular Rectangle (shape of jaw - feeding)

Do humans have a lower or higher BMR than the apes? Why do you think this is?

Brachial Index (upper arm proportions)

Which primates would have brachial index of <100?

Intermembral Index (relative limb length)

Leapers = <100: Lemurs, tarsiers, bush babies (52-70), tamarins, marmosets, capuchins
Suspensory = >100: Chimp (102-106), Gorilla (116), Orang-utan (139), Gibbon (126-147)
Quadrupedal =100: Baboon (95-97), Macaque (84-100)

Cephalic index: (skull shape)

Dolichocephaly: <74.99 = narrow or long-headed
Mesocephaly: 75.00-79.99 = average or medium
Brachycephaly: 80.00-84.99 = broad or round headed
Hyperbrachycephaly: >85.00 = very broad headed

I want to read more about this: Aiello L and Dean C (2002) An introduction to human evolutionary anatomy. QM23.2 AIE. Swindler DR (1973) An atlas of primate gross anatomy: baboon, chimpanzee, and man. QM25 SWI. Jenkins FA (1973) Primate Locomotion. QL737.P9. Fleagle JG (1999) Primate adaptation and Evolution. Academic press.

Where else can I look? The Natural History Museum has exhibits on primates, human evolution, Darwinism and human biology (www.nhm.ac.uk/visit-us/galleries/). London Zoo has a new Gorilla kingdom exhibit and many other smaller primates on show including tamarins, spider monkeys, squirrel monkeys and lemurs (2 new babies just arrived!).

Table 1: Inside information

Modality	Bone	Muscle	Tendon	Cartilage
Fresh cadaver				
Fixed Cadaver				
Skeleton				
Radiograph				
Computed tomography (CT)				
Magnetic resonance imaging				
Ultrasound				

Figure 1 Comparative anatomy of locomotion

Biped	Quadruped

Draw an outline of your body and that of the animal you are working with and annotate with muscle group names

Table 2: Comparative Anatomy of the Locomotor System

Human Notes		
Animal Notes		
	Same	**Different**
1		
2		
3		
4		
5		

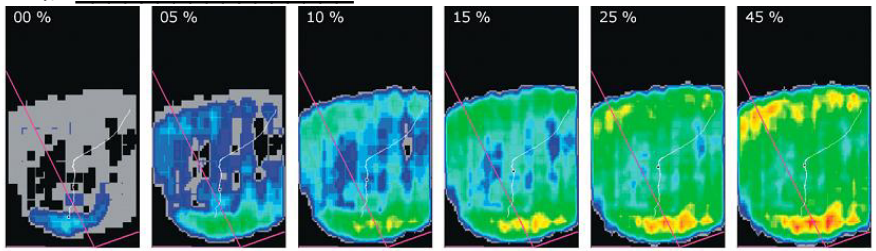
Figure 2A Human pressure record during walking and running **Subject:**

Walking	**Running**
Functional notes:	**Functional notes:**

Sketch your walking and running records here. Note down peak forces and include COP path and areas of high/low pressure. How do the records for walking and running differ? Why do you think this is? Are there any questions you should ask the subject to help you interpret this record correctly?

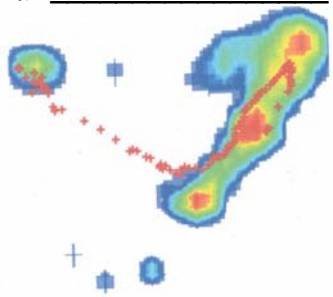
Figure 2B Comparative Foot Function

Animal_____

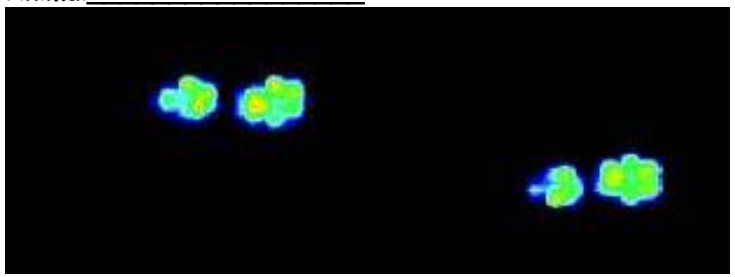


Foot function:

Animal_____ **Foot function:**

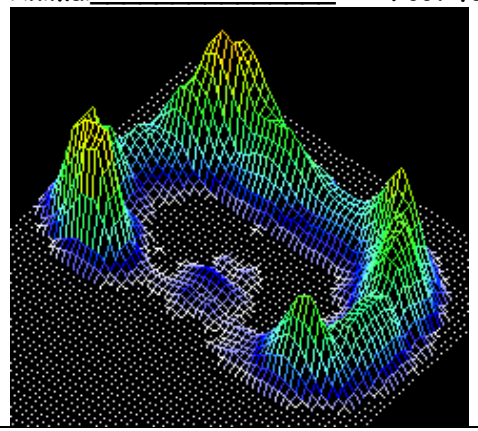


Animal_____



Foot Function:

Animal_____ **Foot function:**



Name the animal. Look at path of CoP and areas of high and low pressure – what does this say about locomotion? What do you think peak GRF is in this animal? Make notes about link between structure and function of foot in each animal.

Table 3 Hominisation Indices

Index	Length 1 (cm)	Length 2 (cm)	Equation	Human	Chimp	Australo-pithecus	Non-primate
Supra-orbital Height	Vertex to S-O margin	Vertex- Frankfurt horizontal	L1/L2 x 100				
Basic Mandibular Rectangle	Mandibular length	Mandibular breadth	L1/L2 x 100				
Brachial	Radius	Humerus	L1/L2 x 100				
Inter Membral	Humerus + radius	Femur + tibia	L1/L2 x 100				
Cephalic	Max head breadth	Max head length	L1/L2 x 100				

Fill in the data as requested above. How do your data compare to the human skeleton on display? Choose a non primate skeleton to compare with your primates – what do the differences/similarities tell you about the animals you have studied here?