Faculty of Medicine

School of Medical Sciences

Department of Anatomy

ANAT3121

VISCERAL ANATOMY
(6 UOC)

Class Notes and Workbook

SESSION 2, 2011

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RULES for ANATOMY STUDENTS

1. Students are required to attend **each lecture & the assigned tutorial/laboratory class** unless given special permission. Provision of an appropriate medical certificate to the course authority will be required for Special Consideration.
2. You may **enter** and **view** specimens in the Dissecting Room 101 **only** in the presence of your tutor and/or during your designated tutorial/laboratory class hours. You are **not allowed** to take visitors into the Dissection Room.
3. Photography and video recording is **not permitted** in the Dissecting Room 101, or the Anatomy Museum 105.
4. **Protocol**: When in the Dissecting Room, you are requested to:
    - **never eat** or **drink**;
    - wear a laboratory **coat** before you enter the lab;
    - if you have forgotten to bring the lab coat for the day, the disposable lab coat can be bought from the ground floor admin offices in WW building or the Union shops on the campus.
    - wear covered **shoes**, not thongs;
    - wear latex or vinyl **gloves** when touching wet specimens (gloves are available from Union Shop near CLB theatres);
    - never put anything in your **mouth**, e.g., biros or pencils that you may have picked up from the table;
    - use blunt **forceps** only to handle specimens and **probes** to point to structures, and **never pull** at any parts of the specimen;
    - as far as possible, **avoid inhaling** preservative solutions for prolonged periods (if you feel in need of fresh air, ask permission to leave the laboratory for a few minutes);
5. **And** at the end of your laboratory:
    - **cover wet specimens** with the towels provided;
    - **replace stools** under the tables in your cubicle;
    - **wash your hands** and instruments.
6. Great **care** should always be exercised when handling specimens, in order to preserve their delicate structure. Much work has gone into the **prosection** of each specimen before it is ready for use in class.
7. You are learning from human material prepared from people who have generously donated their bodies for the benefit of science. Apart from caring for the specimens, it is important for all students learning Anatomy to have and show **utmost respect** for the specimens at all times, in the Dissecting Room, Room 101, and in the Anatomy Museum Room 105. It is **illegal** for any anatomical material to be removed from the premises of the Department of Anatomy for any purpose whatsoever (except of course, for the funeral). All anatomy specimens are micro chipped for identification and record keeping.
8. **Preservative solution**. Most anatomy specimens are stored in 2% phenoxyethanol, which is classified as non-toxic. You should always wear gloves when handling specimens. Detailed information about phenoxyethanol is posted on the Dissecting Room notice board. A few specimens (brain tissue, etc.) are stored in formaldehyde, which is toxic if ingested, and corrosive to the eye; it can also be absorbed through the skin. Formaldehyde is reported to cause allergic skin and respiratory effects. The potential for adverse health effects, however, is markedly reduced at the concentrations used for embalming and storage of specimens in the Dissecting Room, i.e., the "formalin" solution is less than 5% of a 37% solution of formaldehyde. The specimens provided for classes are without any formalin, moreover with air-conditioning the air in the dissecting room is continuously changed. Essentially, you should prevent any preservative solution from coming in direct contact with your eyes, skin or mouth. If assistance is needed during office hours you may approach **Room 101** for **First Aid**.

INDEX

NUMBER	TOPICS WITH TEXT ONLY.
1.	Principles of organisation of the autonomic nervous system
2.	***Appendix 1: Lymphatic system***
3.	Upper respiratory tract: Nose, nasal cavity, larynx and thyroid gland
4.	Thorax, mediastinum and pleura
5.	Lower respiratory tract: trachea, bronchi and lungs
6.	The pericardium and heart
7.	Blood vessels, lymphatics and nerve supply of the thoracic viscera; Cross sectional anatomy of neck and thorax
8.	***Appendix 2: Clinical consideration***
9.	***Appendix 3: Surface anatomy of the neck and thorax***
10.	Mouth, tongue, palate and pharynx
11.	Abdominal wall, inguinal canal and peritoneum
12.	Oesophagus, stomach and coeliac trunk
13.	Duodenum, pancreas and spleen
14.	Small and large intestines and mesenteric vessels
15.	Liver, gall bladder and biliary tree
16.	Blood vessels, lymphatics and nerves of the abdomen and pelvis
17.	Suprarenal gland, kidneys and ureter
18.	Urinary bladder and urethra
19.	Pelvis and perineum
20.	***Appendix 4: Surface anatomy of abdomen & pelvis***
21.	Female reproductive system
22.	Male reproductive system
23.	Blood vessels, lymphatics and nerves of the pelvis and perineum
24.	***Review of autonomic nervous system***
25.	***Appendix 5: Clinical problems***
26.	***Appendix 6: Glossary of anatomical terms***

ABOUT ANAT3121, VISCERAL ANATOMY, 2011

Staff Contact Details:

Course Convenor and Lecturer

Prof. Ken Ashwell
Room 114, No 30 Botany St
ph: 9385 2482
email: k.ashwell@unsw.edu.au

I am available for consultation and discussion by prior appointment via telephone or e-mail. If you cannot attend your appointment, please ensure that you cancel it.

Course details:

ANAT3121 Visceral Anatomy is a 6 UOC course for Science level III, Medical Science, and miscellaneous students. The course extends on teachings from the foundation made by its prerequisites: Introductory Anatomy ANAT2111 or Fundamentals of Anatomy ANAT2511 (a minimum of credit) or ANAT1521 or ANAT1551.

The course provides gross anatomical information regarding the viscera and associated musculoskeletal structure and to a lesser degree the function of the respiratory, cardiovascular, gastrointestinal, urinary, reproductive (male and female), lymphatic and autonomic nervous systems.

Summary of the Course:

ANAT3121 offers a combination of regional and systemic anatomy, according to the schedule of lectures (two per week) and tutorial/laboratory classes (two per week) given below.

This course will focus on gross anatomical study of: Autonomic nervous system, Lymphatic system, Respiratory system, Cardiovascular system, Gastrointestinal system, Urinary system, and Male and Female reproductive system. The student will learn these systems via the prosected wet and plastinated specimens; models and skeleton. The approach also includes topographical, radiological and cross sectional anatomy of the regions. Relevant clinical anatomy in appropriate details is discussed wherever applicable.

Course reviewed in 2009:

In 2009 the course was reviewed and some changes were implemented from the previous year. These include:

- Rules of assessment and you are advised to please read them and beware of the rules.
- The upper respiratory tract includes the nose, nasal cavity and the accompanying gross anatomy.
- The lymphatic system will include the lymphatic drainage of the whole body and therefore the axillary lymph nodes and

the lymphatic drainage of head neck face will be studied in addition to the lymphatic drainage of the thorax, abdomen and pelvis.

Aims of the Course

1. The **aim** of the course is to provide further information, knowledge and understanding of the Gross Anatomy of the organ systems of the human body.

2. In addition the course aims to provide anatomical basis for application to the clinical situations and conditions as well as to the day-to-day activities of an individual in health and disease.

Learning outcomes:

At the completion of the course the student should have:

- A sound knowledge of the gross anatomy of the visceral systems of the body, including the autonomic nervous system and the lymphatic system.
- An application of the knowledge of the living anatomy of the viscera to common clinical conditions.
- An ability to apply knowledge of cross-sectional anatomy to interpretation of radiographs, CT and MRI scans.
- A capacity to apply multi-dimensional learning to the living human being in the states of health, injury and disease.
- A capacity to engage in independent learning and reflection on learning for future scholarly activities after graduation.

Graduate attributes:

"*Graduate attributes are the qualities, skills and understandings a university community agrees its students should develop during their time with the institution.*" Bowden et al (2000), Generic capabilities of ATN universities.

In this course an attempt is made to include the following Science Graduate Attributes http://www2.science.unsw.edu.au/guide/slatig/sciga.html .These are also aligned with the UNSW Graduate Attributes (number in brackets) http://learningandteaching.unsw.edu.au/content/userDocs/grad_attributes.pdf . The students will be encouraged to develop the following Graduate Attributes by undertaking the selected activities and knowledge content. These attributes will be assessed within prescribed assessment tasks.

Full account of Graduate Attribute Policy can be viewed at www.secretariat.unsw.edu.au/acboard/approved_policy/graduate_attributes.pdf

1. ***Research, inquiry and analytical thinking abilities:*** Technical competence and discipline specific knowledge. Ability to construct new concepts or create new understanding through the process of enquiry, critical analysis, problem solving, research. (Aligned with *UNSW*

graduate attribute number: (1) The skills involved in scholarly inquiry & (10) An appreciation of and responsiveness to change).

2. ***Capability and motivation for intellectual development:*** Capacity for creativity, critical evaluation and entrepreneurship. Ability to take responsibility for and demonstrate commitment to their own learning, motivated by curiosity and an appreciation of the value of learning. (Aligned with *UNSW graduate attribute number*: (2) An in depth engagement with relevant disciplinary knowledge in its disciplinary context).
3. ***Ethical, Social and Professional Understanding***: Ability to critically reflect upon broad ethical principles and codes of conduct in order to behave consistently with a personal respect and commitment to ethical practice and social responsibility. Understanding of responsibility to contribute to the community. Respect and value social, multicultural, cultural and personal diversity. (Aligned with *UNSW graduate attribute number*: (3) The capacity for analytical and critical thinking and creative problem solving; (7) An appreciation of and respect for diversity; and (11) A respect for ethical practice and social responsibility).
4. ***Communication*** (Aligned with *UNSW graduate attribute number* 12: The skill of effective communication). Effective and appropriate communication in both professional (intra and inter disciplinary and social (local and international) contexts.
5. ***Ability to engage in independent and reflective learning*** *(UNSW graduate attribute number 4)*
6. ***Teamwork, collaborative and management skills*:** An ability to recognise opportunities and contribute positively to collaborative scientific research, and to perceive the potential value of ideas towards practical applications. Demonstrate a capacity for self-management, teamwork, leadership and decision-making based on open-mindedness, objectivity and reasoned analysis in order to achieve common goals and further the learning of themselves and others. (Aligned with *UNSW graduate attribute number*: (4) the ability to engage in independent and reflective learning; and (9) Skills required for collaborative and multidisciplinary work).
7. ***Information literacy*:** An ability to make appropriate and effective use of information and information technology relevant to their discipline. (Aligned with *UNSW graduate attribute number* (5) Information literacy).

Rationale for the inclusion of content and

The **"Class notes, Lecture notes and Workbook**" contains: relevant information about: the course, prescribed text book,

teaching approach:

atlas and other resources, assessment rules and schedule, lecture and practical timetable, appendices with relevant information and tutorial/lab class.

Under each tutorial/lab class:

- There are aims of the class, that provide an overview of the topic;
- Specific objectives for the lecture;
- Learning activities for identification in the labs; and
- Notes and hand drawn diagrams for use in lectures, labs and at all times for learning.
- The lecture notes are written and included for your guidance and convenience. These lecture notes are sufficient in the details required for this course.
- You **must** however consult a textbook and an atlas for a further clarification.

Teaching Strategies:

Lectures:

- *Please note that the lectures are designed to provide preliminary information and an overview of the topic and are a prerequisite for learning in the labs. Although there will be i-lecture recordings and lecture notes will be posted on BBL, it is advisable for students to attend both lectures for achieving better learning outcomes.*
- Lectures provide an overview of the topic and focus on the: location, structure, relationships to other structures in the vicinity, blood and nerve supply, lymphatic drainage, and functions of the viscera and structures.
- In addition they will address the clinical relevance and surface anatomy, as listed under the specific objectives.
- Cross-sectional anatomy of the region is one of the best ways to visualise the relationship of structures in the body. An attempt has been made to include a few of these for understanding the relationship of the viscera and structures.
- Students **must** have a prior permission from the course authority or there must be a valid and justified reason for not attending the lecture.

Laboratory classes:

- The laboratory classes complement the lectures, and involve active learning in a small group situation. You will be required to study: dry bones, models, wet and plastinated prosected specimens, cross-sectional images (where applicable) and radiographs.
- **Student must attend both laboratory classes, as they are the scheduled learning activities.** The tutors will be taking a rollcall in each lab and report anyone who is absent for

more than two labs in the session.

- It is necessary for the students to know that each student is assigned a laboratory class group with a tutor. It is **compulsory** for the students to stay in their allocated laboratory group for the whole session.
- If you have any concerns about your group/tutor, you may approach your course convener and discuss the matter.
- In the laboratory classes, every student is required to be involved into the inquiry and take an active participation in their learning process.
- **It is the student's responsibility to make sure that all the Aims and Activities of a laboratory are fully understood at the end of each laboratory class**.
- Notes on surface and palpatory anatomy (*see appendix*) have been included, with an aim to developing an ability to apply anatomical knowledge to the living human body. Surface anatomy is examinable via photographs during practical examinations and via questions in written theory examinations.

Study methods:

- A useful suggestion to approach the study of this subject would be to apply the learning of facts and concepts to yourself and the learning of functions to the activities you perform in your daily life, and enjoy the learning! **Appendix on Surface Anatomy** is very helpful for this purpose.
- **Sketching**: Anatomy is a visual discipline. Each laboratory is accompanied by a set of sketch drawings, which demonstrate anatomical concepts or facts. An attempt will be made to label some of the drawings in the lectures. A good set of colour pencils will be useful to bring along in the lectures. Students are encouraged to complete the drawings on their own and sketch bones, muscles, organs – any sketch, no matter how crude or simple, will assist you to learn anatomy.
- Students **must** access a **textbook** and a **colour atlas** of anatomy.
- Remember that prior knowledge from your prerequisite courses is very important. You are expected to use this knowledge and build on it.
- To get the greatest benefit out of your lectures and laboratory classes read the relevant notes prior to each lecture and laboratory class.
- Focus on learning the meaning of the facts and thus develop an understanding rather than memorise for the sake of examination. Remember - learning in this subject goes beyond merely getting good grades or passing the examinations.
- Be consistent with your studies, use sound approaches to

study and approach the course convener if you have any problem.

Time: **Session 2, 2011**

Lectures: **Monday: 2 - 3 pm (Matthews Theatre D)**

Friday: 9 – 10 am (Biomedical Theatre F)

Wks 2 - 13

Labs/tutorials/ Demonstration: **Monday: 3 - 5 pm (Room WW 101 E)**

Friday: 10 - 12 am (Room WW 101 E)

Wks 2 - 13

*Please note that both labs are **compulsory** and each student is required to attend them. Please attend the lab at your scheduled time and remain in your assigned lab group. You **must attain 80% of attendance** (see below in Conduct of Students).*

Absence for more than two labs for whatever reasons must be reported to the course authority as it may affect your legibility to attend the assessment/s.

Blackboard (BBL): This course uses **BBL** for lecture notes, accessory lecture notes (wherever applicable), assessment, announcements and discussions. More information regarding instructions and requirements will appear on **BBL** under announcements and a pop-up message will appear when you log on to **BBL**. Be advised that **BBL** discussion is strictly for education requirements related to this course. Students must not use this for personal or social discussions. I monitor this section for its proper use and it will be withdrawn if there is a misuse of this resource.

Assessment: Spot tests assess the ability of the student to identify and name correctly significant structures in human anatomical specimens, models and radiographs.

Spot Test I	**20% on Monday 29th August 2-4 pm**
Spot Test II	**30% during the examination period**
Final Examination	**50% during the examination period**

NOTE:

Assessment pass mark for this course is **50%**. There are two components of this course:

1) The **practical component 50%** (contributed by spot test 1 and spot test 2 together) and

2) The **theory component 50%**.

Students are expected to pass **each component** (practical and theory) with a minimum of **50% marks**. The students, who pass overall but fail in a component (e.g., the practical or final theory examination) **may** be re-examined in that component, depending on their attendance record, the nature and extent of the failure and performance in other components. This is discussed and decided by the Course Authority and the Assessment Committee. Students will be notified of their results as WC or WD if they are required to sit for a supplementary test.

Re-examination by supplementary examination/s in any component for reasons of failure will be on a pass/fail basis only. The supplementary examinations will have the similar level of difficulty but may not follow the same pattern as for the original examination. The course authority usually will discuss the patterns of examination with the other academics who teach the course, or in some cases with the Head of Teaching in the Department.

Remember it is the student's responsibility to contact the course authority with regard to absences from tests. Also remember it is the students responsibility to be familiar with the rules governing the conduct of examinations.

Supplementary examination in the course is scheduled for early December 2011. Please do not book your holidays and trips until the final results are disclosed.

University policy regarding releasing marks, privacy and student appeals can be found at the following site:

https://my.unsw.edu.au/student/academiclife/assessment/AssessmentatUNSW.html

(Instructions: click on "Results" which is up the top of this web page, and then "Finalisation of assessment results and appeals procedures" which is down the bottom of the next page.

Special consideration – Illness or misadventure:

Quote from the website:

"Sickness, misadventure, or other circumstance beyond your control may prevent you from completing a course requirement or attending or submitting assessable work for a course, or may significantly affect your performance in assessable work, e.g. formal end of session examination, class test, laboratory test, seminar presentation, etc.

You can apply for consideration for the affected assessments.

Note:

1. Depending on the circumstances, the University may take action to allow you to overcome the disadvantage, e.g. give you

additional assessment or extend a deadline.

2. Merely submitting a request for Special Consideration does not automatically mean that you will be granted additional assessment, nor that you will be awarded an amended result. For example, if you have a poor record of attendance or performance throughout a session/year in a course you may be failed regardless of illness or other reason affecting a final examination in that course.

3. The University has a centralised procedure for Special Consideration applications. Many course authorities and Faculties have 'local' procedures that you will also need to follow.

4. It sometimes happens that a student may encounter a situation that is so significant or personal they do not want to use the Special Consideration procedures. In a case like this you may prefer to contact the University Health Service, the Counselling Service, an academic adviser in your program office or the Manager, Student Administration and Records. Remember that it is always important to let the University know if there is anything that may affect your ability to continue your studies." (unquote).

Note:

If a student is so sick to attend the lectures and laboratory classes and appear for assessments, they should consult the Counselling service and/or the University Health services and follow the instructions. Remember - the assessments are distributed over the session to spread the load.

Spot Tests:

Spot tests contribute to 50 % of your assessment and assess the ability of the student to identify and name correctly significant structures in human anatomical specimens, models and radiographs.

The structures listed in the learning activities (regardless of whether they are in bold or un-bold, will be assessed for identification and the gross anatomical information regarding the structure and function is tested via theory questions within a question of the spot test.

You must read the lecture notes provided and the prescribed textbook for your factual knowledge of the topic. The atlas helps to make a visual picture with its application to the specimens and/or models.

Specific objectives listed under the heading of the lab/tutorial in the workbook/manual will help in outlining these topics.

Students who fail the first spot test should consult their tutor/course co-ordinator for advice as soon as possible and be prepared to alter their methods of study and techniques of preparation for Tut/Lab classes.

Spot Test Instructions: (subject to change)

1. 12 questions, usually with a few rest seats when/where provided.
2. Each question consists of 4 - 5 identifications; followed by 2 - 3 theory questions based on the laboratory class notes.
3. Bring 2 pens (in case 1 fails); answer sheets are provided.
4. About 3 min. is allowed per question/rest seat; a beeper indicates the time to move to the next question or a rest seat.
5. You will be instructed to put a circle around the question you are starting with, and to move to your left when the beeper sounds.
6. Make sure you are on the correct question every time you move.
7. Always name specifically the first structure through which the pin passes.
8. Do not touch the specimens or the flags.
9. It is an OHS requirement that **you must wear your lab coat and proper closed shoes** to the spot test.
10. **You must arrange to have a disposable lab coat for the day in the event that you have forgotten to bring one to the test.**
11. **Please switch off your mobile phone before you enter the dissecting room.**

Final theory Examination:

- During examination period
- Time: **2 hours** (120 minutes)
- Consists of material learnt within wks **1 – 13** in this course.
- Refer to the specific objectives of each topic for direction.
- The final theory examination consists of **two** parts:
  1. **Part A: 40 multiple choice questions 50%**
  2. **Part B: 2 essay questions 50% (25 minutes each)**

Supplementary examination:

Supplementary examination:

Additional assessment
https://my.unsw.edu.au/student/atoz/SpecialConsideration.html

Quote from the website:

"The time at which any additional assessment granted to you is held is determined by the course authority concerned. Consult the course information sheet for detailed information about the times and arrangements for the various additional assessment tasks in that course.

Most course authorities conduct supplementary examinations in the period immediately after the formal end of session examination period. For example, for the end of Session 2, supplementary examinations are often held in the three-week period just prior to Christmas. In general, course authorities will provide only one opportunity for you to sit a supplementary examination except in exceptional circumstances. You need to ensure you will be available during this period to take any supplementary examination granted to you.

You should expect any additional assessment granted to you to be of the same degree of difficulty as the original assessment task which it replaces."

Note:

The supplementary examination for ANAT3121 in 2011 will be organised within the first week of December 2011.

The concerned students will be required to consult the Course Authority for the details of times and location.

Academic Honesty & Plagiarism:

The students are reminded that cheating on someone else's work during examination (practical or theory) is classified under academic dishonesty. The student link for Plagiarism and Academic Integrity is at

http://www.lc.unsw.edu.au/plagiarism/link.html. This website also has information on academic misconduct and it is advisable to be familiar with the University policies.

There are no assignments in this course, but the following is included here for your information:
Plagiarism is the presentation of the thoughts or work of another as one's own.

Examples include:

- Direct duplication of the thoughts or work of another, including by copying work, or knowingly permitting it to be copied. This includes copying material, ideas or concepts from a book, article, report or other written document (whether published or unpublished), composition, artwork, design, drawing, circuitry, computer program or software, web site, Internet, other electronic resource, or another person's assignment without appropriate acknowledgement;
- Paraphrasing another person's work with very minor changes keeping the meaning, form and/or progression of ideas of the original;
- Piecing together sections of the work of others into a new whole;
- Presenting an assessment item as independent work when it has been produced in whole or part in collusion with other people, for example, another student or a tutor; and,

- Claiming credit for a proportion a work contributed to a group assessment item that is greater than that actually contributed.†
- Submitting an assessment item that has already been submitted for academic credit elsewhere may also be considered plagiarism.
- The inclusion of the thoughts or work of another with attribution appropriate to the academic discipline does not amount to plagiarism.
- Students are reminded of their Rights and Responsibilities in respect of plagiarism, as set out in the University Undergraduate and Postgraduate Handbooks, and are encouraged to seek advice from academic staff whenever necessary to ensure they avoid plagiarism in all its forms.
- The Learning Centre website is the central University online resource for staff and student information on plagiarism and academic honesty. Individual assistance if requested is available from The Learning Centre. It can be located at: www.lc.unsw.edu.au/plagiarism .The Learning Centre also provides substantial educational written materials, workshops, and tutorials to aid students in:
- Correct referencing practices; paraphrasing, summarising, essay writing, and time management; appropriate use of, and attribution for, a range of materials including text, images, formulae and concepts.
- Students are also reminded that careful time management is an important part of study and one of the identified causes of plagiarism is poor time management. Students should allow sufficient time for research, drafting, and the proper referencing of sources in preparing all assessment items.

* Based on that proposed to the University of Newcastle by the St James Ethics Centre. Used with kind permission from the University of Newcastle

† ***Adapted with kind permission from the University of Melbourne.***

Course Schedule, 2011

Suggested reading for each topic is provided but **remember** to consult the relevant topics in your Textbook and Atlas for further information. Pdf Lecture slides will be posted on BBL after every lecture and they are complementary to the notes in your workbook.

Week	Date	Lecture & Practical/Lab	Suggested reading
2	**25/7**	Lect 1. The principles and organisation of the autonomic nervous system	Class notes for lecture and lab 1
		Lab 1. Autonomic nervous system	
2	**29/7**	Lect 2. The upper respiratory tract: Nose, nasal cavity, air sinuses, larynx & thyroid gland	Class notes for lecture and lab 2
		Lab 2. Upper respiratory tract: Nose, nasal cavity, air sinusel, Larynx & thyroid gland	
3	**1/8**	Lect 3. The thorax, mediastinum and pleura	Class notes for lecture and lab 3
		Lab 3. The thorax, mediastinum and pleura	
3	**5/8**	Lect 4. Lower respiratory tract: Trachea, bronchi and lungs	Class notes for lecture and lab 4
		Lab 4. Lower respiratory tract: Trachea, bronchi and lungs	
4	**8/8**	Lect 5. The Pericardium & heart	Class notes for lecture and lab 5
		Lab 5. The Pericardium & heart	
4	**12/8**	Lect 6. The blood vessels, lymphatics and nerve supply of the thoracic viscera; Cross-sectional anatomy of neck and thorax	Class notes for lecture and lab 6
		Lab 6. The Blood vessels, lymphatics and Nerve Supply of Thoracic viscera; Cross Sectional anatomy of Neck and Thorax	
5	**15/8**	Lect 7. The mouth, tongue, palate and pharynx	Class notes for lecture and lab 7
		Lab 7. The mouth, tongue, palate and pharynx	
5	**19/8**	Lect 8. Abdominal wall, inguinal canal and peritoneum	Class notes for lecture and lab 8
		Lab 8. Abdominal wall, inguinal canal and peritoneum	
6	**22/8**	Lect 9. The oesophagus, stomach and coeliac trunk	Class notes for lecture and lab 9
		Lab 9. The oesophagus, stomach and coeliac trunk	
6	**26/8**	No lecture: revision in laboratory	Class notes for lecture and lab 1-9

		Lab 10. revision in laboratory	Class notes for lecture and lab 1-9
7	**29/8**	**No Lecture! Spot Test 1 20%; Labs 1 – 10 / Weeks 2 - 6 (inclusive); (Room 101 W: 1 - 4pm)**	
7	**2/9**	Lect 11. The duodenum, pancreas & spleen	Class notes for lecture and lab 11
		Lab 11. The duodenum, pancreas & spleen	
		Mid-session Recess 3/9 - 11/9	
8	**12/9**	Lect 12. The small & large intestine & mesenteric vessels	Class notes for lecture and lab 12
		Lab 12. The small & large intestine & mesenteric vessels	
8	**16/9**	Lect 13. The liver, gall bladder & biliary tree	Class notes for lecture and lab 13
		Lab 13. The liver, gall bladder & biliary tree	
9	**19/9**	Lect 14. Blood vessels, lymphatics & nerves of the abdomen	Class notes for lecture and lab 14
		Lab 14. Blood vessels, lymphatics & nerves of the abdomen	
9	**23/9**	Lect 15. The suprarenal glands, kidneys & ureters	Class notes for lecture and lab 15
		Lab 15. The suprarenal glands, kidneys & ureters	
10	**26/9**	Lect 16. The urinary bladder, prostate & urethra	Class notes for lecture and lab 16
		Lab 16. The urinary bladder, prostate & urethra	
10	**30/9**	Lect 17. Pelvis and perineum	Class notes for lecture and lab 17
		Lab 17. Pelvis and Perineum	
11	**3/10**	**No lecture, no lab, Labour Day Holiday!**	
11	**7/10**	Lect 18. Female reproductive system	Class notes for lecture and lab 18
		Lab 18. Female reproductive system	
12	**10/10**	Lect 19. Male reproductive system	Class notes for lecture and lab 19
		Lab 19. Male reproductive system	
12	**14/10**	Lect 20. Blood vessels, lymphatics & nerves of the pelvis	Class notes for lecture and lab 20
		Lab 20. Blood vessels, lymphatics & nerves of the pelvis	

13	**17/10**	Lect 21. Review of autonomic nervous system	Class notes for lecture and lab 21
		Lab 21. Review of autonomic nervous system	
13	**21/10**	Lect 22. Radiology; cross-sectional anatomy of abdomen and pelvis	
		Lab 22. Surface anatomy video and radiographs	Appendix notes on surface anatomy.

SPOT TEST 2, 30% (Material learnt from Wk 7- Wk 13)

Labs 11-22.

Room 101 W: During examination period

A revision class will be held during study vacation.

Supplementary test/s: 1st week of December 2011

Expected resources for the students	**Every student in this course is expected to have a textbook and an atlas of their personal choice/preference. You may bring your atlas with you to the lab classes, for quick reference, but be careful for its safety**.
Text Book:	Moore, KL. *Clinically Oriented Anatomy*, 6th edition, Williams & Wilkins **or** Drake, RL, Vogl W and Mitchell AWM, *Gray's Anatomy for Students*, Elsevier Churchill Livingstone
Recommended Atlas:	Rohen, JW, Yokochi, C. & Lutjen-Drecoll. *Color Atlas of Anatomy*, Lippincott Williams & Wilkins, 7th Edition **or** Netter, FH. *Atlas of Human Anatomy*, Novartis, 4th or 5th edition **or** Agur, AMR & Lee, MJ. *Grant's Atlas of Anatomy*, Lippincott Williams & Wilkins, **or** Abrahams PH, Boon JM and Sdpratt JD. *McMinn's Clinical Atlas of Human Anatomy,* Mosby Elsevier, 2008
Reference books:	Hull, Lippincott Williams and Wilkins, Colouring atlas of the human body. Marieb, EN & Hoehn K, *Human Anatomy and Physiology* + CD 7th edition, Pearson Benjamin cunnings. Martini FH, *Fundamentals of Anatomy and Physiology*, Pearson Benjamin cunnings. Robert D. Acland, FRCS, Acland's Cross-Sectional Navigator, Lippincott Williams And Wilkins.

Other Resources:

Anatomy Images CD-ROM produced in Department of Anatomy is available to the students for purchasing at $15 each from the SOMS administration office, Room MG14, Wallace Wurth Building. Some of you may already own this from your previous Anatomy course. This CD-ROM contains images of the specimens, models etc. used in the dissecting room and have a command available for self-test. Students in the past have found it a very useful learning resource.

Glossary & **Spelling**: Correct spelling of terms and concept is important in any discipline – please learn to use the **Glossary** at the end of these notes. The M.A. Arnold Glossary is also available online at: http://medicalsciences.med.unsw.edu.au/SOMSWeb.nsf/page/Science+Current+Students/. You may use anatomical abbreviations given in this glossary.

Anatomy Museum is located in Room 105, Wallace Wurth Building and is accessible using your student card as a swipe card. Please note that for access to the Anatomy Museum, your card must be encoded at the UNSW Security Office in the Red Centre after the start of the Session.

Skilfully dissected specimens have been mounted in glass bottles in the Anatomy Museum **Room 105**. In 2001, under the project "3-D Real Human Atlas", extensively labelled and catalogued prosected human specimens were created as an additional resource to the variety of learning resources that have been made available to the students.

The main aim of the museum is to support student learning with the availability of bones, models, and excellent quality specimens for revision. In addition these provide flexibility to the students to study in their own time. It helps students to get involved in peer learning, discussions, self-directed learning and self-assessment.

Safety in the museum:

- Always handle museum specimens with care and respect. All specimens consist of generously donated human tissue and have been painstakingly dissected by the staff, many of whom have passed on, thus making them extremely precious and irreplaceable.
- The specimens are preserved in fixative solutions, which contain a variety of toxic compounds.
- Students are requested to be extremely careful around the jars and the display cabinets.
- For reasons of hygiene and OHS issues, never take food or drink into the museum.
- Do not move the specimens from their shelves. Never leave a museum specimen on the floor, or in any precarious position.
- If a specimen is leaking, turn it upside down to prevent further leakage, then immediately inform Mr Vincent Strack or anyone in the service area of the dissecting room or a member of academic staff.
- If a specimen is broken, do not attempt to wipe up the spillage. You must immediately inform Mr Vincent Strack or anyone in the service area of the dissecting room or a member of academic staff.
- Remember that a lot of goodwill of the donors and work and time of the staff has been devoted to the museum for your benefit. Thus

your cooperation in maintaining neatness and safety at all times is appreciated.

Library Resources:

Ms Kate Dunn, the Outreach librarian, University library, The UNSW has kindly provided following links and information for the students to use as additional resources.

·Primal Pictures <http://info.library.unsw.edu.au/cgi-bin/local/access/access.cgi?url=http://ovidsp.ovid.com/ovidweb.cgi?T=JS&MODE=ovid&PAGE=main&NEWS=n&DBC=y&D=ppen> 3D interactive anatomy database

·Library Subject Guide for Anatomy http://subjectguides.library.unsw.edu.au/content.php?pid=8701&sid=56148

<http://subjectguides.library.unsw.edu.au/content.php?pid=8701&sid=56148>

·The Library holds a variety of 3D anatomical models for students: They are housed in My Course Reserve, level 2.

Course evaluation and development (CATEI)

The student evaluative feedback on the course is gathered, using UNSW Course and Teaching Evaluation and Improvement (CATEI) Process. There will be **three** forms that the students will be requested to fill in towards the end of the semester. These questionnaires are available on-line as well as on paper. Depending on the availability of time the students will be advised in time and will be requested to provide feedback on the course (Form A) and the teachers (lecturer Form B) and tutor/demonstrator (Form C). Student feedback is taken seriously, and continual improvements are made to the course based in part on such feedback.

The course authority also seeks feedback and constructive comments from the teachers in the course.

Other important information for students

Conduct of students:

The University takes academic misconduct seriously. The information regarding this can be found at: http://my.unsw.edu.au/student/academiclife/assessment/AcademicMisconductStudentMisconduct.html

It is your civil responsibility to be aware of your conduct in regards to: mutual respect and respect for the donated materials, social, multicultural, cultural and personal diversity.

Dissecting Room.

- You may enter and view specimens in the Dissecting Room 101 **only** in the presence of your tutor and/or during your designated and or scheduled laboratory class hours. Please read the ***RULES for ANATOMY STUDENTS*** for your conduct in the lab classes.
- You are not allowed to take **any** visitors into the Dissection Room.
- Satisfactory attendance at lectures and tutorial/laboratory classes is mandatory.

- Every illness or misadventure should be supported by a relevant medical certificate and submitted to the Student Central within **3** working days of the event. The students who do not report and submit the medical certificate via the **Student Central, UNSW** within the required period limit, will not be considered.

Applications for Consideration.

Students who miss an assessment through illness or misadventure must submit an application for consideration within **three** working days to Student Central, UNSW. Full details for the application (e.g., Medical Certificate, etc.) are available at http://my.unsw.edu.au/student/academiclife/assessment/AssessmentatUNSW.html

- **Laboratory coats must be worn in the Anatomy Laboratory. Closed shoes that cover the full front and back of the foot are a must to wear. You must wear gloves when handling wet specimens**. You must remember to bring your Lab coats but in case of emergency, cheap disposable lab coats can be purchased from some of the UNSW shops. Thin disposable gloves can be bought in bulk from supermarkets; **bring at least two pairs for each lab**. **Mobile phones must be switched off during the lectures and laboratory classes**.
- Every illness or misadventure should be supported by a relevant medical certificate and submitted to the Student Central within 3 working days of the event. The students who do not report and submit the medical certificate via the **Student Central, UNSW** will not be considered.
- Supplementary rules and conduct for students in the Department of Anatomy are listed under ***RULES for ANATOMY STUDENTS***.

Student support services:

Those students who have a disability or a medical condition that requires some adjustment in their teaching or learning and/or examination environment are encouraged to discuss their needs with the Course Convenor prior to, or at the commencement of their course. All these cases should also be reported with the Equity Officer (Disability) at: (9385 4734) or

http://www.studentequity.unsw.edu.au/disabil.html

Issues to be discussed may include access to materials, signers or note-takers, the provision of services and additional examination and assessment arrangements. Early notification is essential to enable any necessary adjustments to be made. As far as possible do not plan elective surgery or medical appointments during your lecture or lab times, as these will disrupt your own learning.

Information on designing courses and course outlines that take into account the needs of students with disabilities can be found at:

http://www.studentequity.unsw.edu.au/disabil.html

Administrative Matters:

Students are expected to attend both lectures and both tutorial/laboratory classes that they have enrolled into, each week.

Please do not change your groups without consulting with your course authority.

You must study the relevant notes before each lecture & **tutorial/laboratory class**. This makes the understanding in the lecture easier. Additional notes when applicable **<u>may</u>** be available on the course homepage on BBL.

Anatomy is a visual subject and hence to facilitate student learning the lecturer uses some relevant diagrams (these are included in your workbook).

Students are also expected to check the BBL regularly for announcements, tests and/or additional resources. You will get an e-mail notification of any new activity on BBL and it remains your responsibility to make yourself aware of the activity.

Students are encouraged to use the discussion part of the BBL for their questions related to their course material. You must attempt to answer questions for instant feedback on your learning. These questions can be answered/with corrections or suggestions by your peers and/or the course authority. Remember the content and quality of discussion is regularly monitored by the course authority.

Administrative staff:

Ms. Marie Kwok
Position: Administrative Officer (Anatomy)
Location: Administrative Wing, Room MG14, Ground floor Wallace Wurth Building
Contact number: 9385 2480
Ms Kwok is responsible for the matters related to the administration of Department of Anatomy. She can assist in arranging interviews with academic staff within the Department as well as sale and delivery of CD-ROMs to students.

Ms. Carmen Robinson
Position: Student Advisor
Location: Administrative Wing, Room 217, Ground floor Biosciences Building
Contact number: 9385 2464
Ms Robinson is responsible for general administration and student support within the School of Medical Sciences.

Mr. Vincent Strack
Position: Manager Dissecting Room
Location: Level 1 Room 101 Wallace Wurth Building
Mr Strack will not be in direct contact with the students but provides support for all Anatomy Museum related issues. Mr. Strack and his office staff can be contacted regarding lost property within the premises of the dissecting room and/or the Anatomy Museum.

Ms. Jennifer Heartley
Position: OH&S Co-ordinator for SOMS
Location: Administrative Wing, Room MG14, Ground floor Wallace Wurth Building
Ms Heartley is in-charge of the OH&S issues within the Wallace Wurth Building.
Contact number: 9385 8288

Official communication

Students in this course ANAT3121 are advised that e-mail is the official means by which the School of Medical Sciences at UNSW will communicate with you.

All email messages will be sent **only** to **your official UNSW email address** (e.g., z1234567@student.unsw.edu.au). If you do not wish to use this student address, you **must at your end** arrange for your official mail to be forwarded to your chosen address.

It is recommended that you check your mail at least once a day. Facilities for checking email are available in the School of Medical Sciences and in the University Library. The UNSW Library runs free email courses.

Students should make sure that their home address and telephone number(s) that are listed on the UNSW files are current and may wish to provide their alternate contact numbers (e.g. **mobile number**) for contact in case of need.

Occupational Health and Safety (OHS) Rules:

OH&S enquiries and issues are taken seriously in School of Medical Sciences (SOMS) and you must not hesitate to approach any staff with your issue. The SOMS has general rules for ensuring safety of staff and students at:
http://medicalsciences.med.unsw.edu.au/somsweb.nsf/page/Undergraduate%20Current%20Students

'Safety Summary for all Students and Supervisors' is a pdf file, which can be downloaded and read from the above site. Please be informed that this site is currently being updated and will certainly be available by the beginning of TP1.

For more information on matters related to occupational and health safety policies of the UNSW visit the following web site.

http://www.hr.unsw.edu.au/ohswc/ohs/ohs_policies.html

NB. You must wear **laboratory coats** and **closed shoes** in the laboratory and bring **gloves** to all laboratory classes, especially for handling the wet and dry specimens during the Tutorial/Laboratory.

Lost Property:

You must be careful with your personal belongings at all times, it remains your responsibility. In case you have misplaced or left behind your personal items, Anatomy manual, textbook, etc. in the lab, you may check with the staff in Service Room inside the Anatomy Dissecting Room 101.

However there is no guarantee that you will find what you lost, so be careful to protect your possessions. When entering the dissecting room you must bring all your belongings inside the room.

Please hand in any found items to your tutor or the staff in the Service Room.

Grievances:

Grievance Procedure

For guidance regarding grievance matters visit the website:

www.gs.unsw.edu.au/policy/documents/studentcomplaintproc.pdf

If you have any problems or grievance about this course, you should try to resolve it first with the Course Organizer or Course Convenor. If the grievance cannot be resolved in this way, you should contact the Grievance officer or alternatively the Head of Department of Anatomy.

You are required to put an application in confidence with the grievance officer, stating the reason and concern.

The Grievance Officer of the School of Medical Sciences is currently:

Dr. Priti Pandey
Room G211, John Goodsell Blg
Ph: 9385 2483
E-mail: p.pandey@unsw.edu.au

Acknowledgement

The original text notes that follow in this manual were received with thanks from Dr P. Pandey (2010). These notes have been revised, rewritten and amended.

Relevant hand-drawn diagrams are included as a relevant resource for visual learning in the subject.

A positive and constructive feedback on behalf of the readers will be very much appreciated for further and future improvements.

TUTORIAL/LABORATORY CLASS 1
THE PRINCIPLES OF ORGANISATION OF THE AUTONOMIC NERVOUS SYSTEM (ANS)

Aims: To understand the principles of organisation of the autonomic nervous system (ANS)

Specific Objectives

1. To compare and contrast the basic structure of the somatic and autonomic (visceral) nervous systems.
2. To identify the sites of origin of the preganglionic sympathetic and parasympathetic neurones.
3. To define the distribution of preganglionic and postganglionic sympathetic fibres.
4. To define the distribution of preganglionic and postganglionic parasympathetic innervation with specific cranial and sacral nerves.
5. To summarize the action of the sympathetic and parasympathetic systems.
6. To describe the formation, contribution and distribution of the autonomic plexuses.

Learning activities

1. **Sympathetic trunk**: On the prosected specimens: Identify the **sympathetic trunk** in the neck, thorax, abdomen and pelvis and grey and white **rami communicantes** in the thorax. Identify the **superior & middle cervical ganglia**, in the neck and the **stellate (cervicothoracic) ganglion** at the neck of the first rib, in the upper thorax. Discuss the distribution of preganglionic fibres to the cervical ganglia, and the distribution of the post-ganglionic fibres from these ganglia to the smooth muscles and glands of the head and neck.
2. Identify the **greater, lesser** and **least** (may not be present/visible) **splanchnic nerves** and **coeliac ganglion**. *Which segments of the spinal cord contribute to the formation of these nerves? What is their destination and how do they reach there? What is their area of distribution?*

3. Identify the **lumbar splanchnic nerves** and the sacral splanchnic nerves (if present). *Which segments of the spinal cord contribute to the formation of these nerves? What is their destination and how do they reach there? What is their area of distribution?*
4. On prosected specimens and models of infratemporal fossa identify the **lingual** branch of mandibular nerve and the **chorda tympani** branch of the facial nerve. *Where does the chorda tympani originate and what foramen does it pass through before it joins the lingual nerve? Discuss what type of fibres are carried by chorda tympani nerve, which ganglion do they synapse and what are the targets for these fibres?*
5. On prosected specimens and models identify the **facial nerve**. *Discuss the distribution of parasympathetic fibres carried in facial nerve. Where do the parasympathetic fibres in facial nerve originate, which ganglia do they synapse and what are the target structures for the postganglionic fibres?*
6. On prosected specimens and/or models identify the **glossopharyngeal nerve**. *Discuss the distribution of parasympathetic nerve fibres carried in glossopharyngeal nerve. Where do the parasympathetic fibres in glossopharyngeal nerve originate, which ganglia do they synapse and what are the target structures for the postganglionic fibres?*
7. Identify the **right** and **left vagus nerves**. Note that the **right vagus** nerve crosses in front of the first part of the right subclavian artery, behind the SVC and descends in the superior mediastinum at the right side of the trachea and the pulmonary (autonomic) plexus, and then continues to the esophagus forming the esophageal plexus. The **left vagus** nerve enters the thorax between the left common carotid and left subclavian arteries. It descends in the superior mediastinum, crosses the left side of the arch of aorta and then enters the esophageal plexus. At the lower part of the esophagus, the plexus divides into **anterior and posterior vagal trunks**, which descend through the esophageal opening. The anterior trunk descends on the anterior aspect of the stomach and gives off branches to the liver and stomach. The posterior vagal trunk descends along the posterior wall of esophagus, passes through the esophageal opening and supplies a large **coeliac branch**, which passes to the **coeliac plexus** and to the **superior mesenteric plexus**. The vagal fibres that enter the coeliac and superior mesenteric plexuses supply the stomach, pancreas, liver, small intestine and the large intestine as far as the left colic flexure (i.e. fore- and midgut derivatives). Each vagus nerve has a branch called the **recurrent laryngeal nerve**. Recurrent laryngeal nerve is a mixed nerve with both motor and sensory fibres, which supply the larynx, trachea and esophagus.
8. Identify the **pelvic splanchic nerves** in prosected specimens of deep abdomen and lateral pelvic wall. Discuss their site of origin and distribution and function.
9. Identify the cardiac plexuses, superficial and deep) and *discuss the contribution of the cardiac plexuses and their distribution to the thoracic viscera. Discuss the input of sympathetic and parasympathetic fibres into these plexuses. What are the areas of distribution of these plexuses? What are the locations, communications and extensions of these plexuses?*
10. Identify the following **prevertebral plexuses** of the abdomen and pelvis: **coeliac**, **superior** and **inferior mesenteric**, **intermesenteric plexus** (between superior and inferior mesenteric arteries), **aortic plexus** (between the inferior mesenteric plexus and the bifurcation of abdominal aorta), the **superior hypogastric plexus** (from the level of bifurcation of aorta and on the ventral surface of the upper part of sacrum)**,** the **right and left hypogastric nerves** (branches of the superior hypogastric plexus), and **inferior hypogastric/pelvic plexuses** (originating at the inferior end of right and left hypogastric nerves to lie on the lateral walls of the pelvis). Note that prevertebral ganglia are found in the prevertebral plexuses. *Discuss the input of sympathetic and parasympathetic fibres into these plexuses. What are the areas of distribution of these plexuses? What are the locations, communications and extensions of these plexuses?*
11. Discuss the differences between **pelvic** and **lumbar splanchnic nerves**.
12. Discuss **clinical problem 1**.

Lecture Notes

Introduction

The **autonomic nervous system (ANS)** is an efferent (motor) system that supplies and regulates the activities of the smooth muscles, cardiac muscle and glands. It also has an effect on the adipose tissue of the body. Thus the sympathetic system mobilizes energy reserves by releasing the lipids and the parasympathetic system creates energy reserves in the form of lipids.

The ANS operates at various levels: the highest level is at the (central nervous system). ANS is an involuntary system, and thus works at the subconscious level. It supplies the smooth muscles, cardiac muscle and glands of the body. All its axons are efferent fibres, which transmit impulses from the central nervous system to visceral effectors. In addition, the impulses that give rise to visceral sensations pass over visceral afferent neurons that have cell bodies located in the spinal ganglia or other sensory ganglia of the spinal or cranial nerves.

Function of the Autonomic Nervous System

1) Regulation and coordination of visceral activities
2) Maintain constancy of the internal environment: homeostasis
3) Regulate body temperature
4) Adjust visceral activities to emotional behavior.

Somatic vs Autonomic effector Nervous Systems:

Somatic Nervous System

- Effector neurones lie entirely within the CNS
- Stimulation causes excitation and contraction of muscles
- Axons are myelinated
- Only one neuron is interposed between the central nervous connections and effectors
- The only transmitter used is Acetylcholine

Autonomic Nervous system

- Effector neurones lie in both CNS and peripheral ganglia
- Stimulation causes excitation or inhibition
- Axons may be myelinated or unmyelinated
- At least two neurons are interposed between the central nervous connections and the visceral effectors
- Acetylcholine, Adrenalin and Noradrenaline are used as transmitters

	SOMATIC SYSTEM	**AUTONOMIC SYSTEM**
Structures Supplied	Skeletal muscles	Smooth and cardiac muscles, glands and adipose tissue
Nature Of System	Voluntary (under control of will)	Involuntary (no control of will)
Effect	Excitatory	Excitatory or inhibitory
Role	Contraction of skeletal muscles so produces movements	Homeostasis, harmony of vital functions
Neurons	One in CNS (cranial nerve nuclei or ventral horn of spinal cord)	Two; first order in CNS (Cranial nerve nuclei or lateral horn of spinal cord; second order in peripheral autonomic ganglia
Ganglia	None	Paravertebral sympathetic chain or Prevertebral ganglia (sympathetic); and peripheral ganglia or terminal ganglia (parasympathetic)

Divisions of the ANS

I Parasympathetic: Craniosacral outflow

II Sympathetic: Thoracolumbar outflow

Some definitions:

Neurons: Two-neuron system with preganglionic neuron in the CNS and postganglionic neuron in the periphery.
Ganglion: contains preganglionic axon terminals and postganglionic cells.
Autonomic Plexus: formed by network of nerve fibres, both sympathetic and parasympathetic.
Visceral Afferents
These resemble somatic afferent pathways; the cells of origin of their peripheral fibres are pseudounipolar neurons in cranial and dorsal root ganglia. Peripheral processes are distributed through autonomic ganglia or plexuses, or possibly through somatic nerves, without interruption. Central processes project to brain and spinal cord.

COMPARISON of SYMPATHETIC & PARASYMPATHETIC DIVISIONS		
	SYMPATHETIC	**PARASYMPATHETIC**
General Distribution	Somatic as well as visceral	Entirely visceral
Heart	Increase heart rate and strength of contraction Dilate coronary vessels	Decrease rate, has little effect on strength of contraction (this is how it conserves & restores energy!)
Bronchi	Dilates	Constricts, increases bronchial secretions
Pupil	Dilates (mydriasis)	Constricts (miosis)
Ciliary body		Contracts the ciliary muscle, decreases tension of suspensory ligaments and makes the lens more convex. Required for the process of accommodation or near vision/reading.
Lacrimal gland		Stimulates lacrimation/tear secretion
Blood Vessels	**Vasoconstriction** in general of skin and viscera, and **vasodilation** and thus shifting blood to brain, skeletal muscles and heart *Note: Blood pressure is normally controlled by the sympathetic system.*	No effect in many blood vessels
Sweat Glands	Stimulated (ACH)	No effect
Adrenals	Stimulates secretion of epinephrine and norepinephrine	No effect
Salivary Glands	Vasoconstriction and thus stimulates thick viscous saliva	Stimulate profuse, watery saliva

Intestines	Inhibits motility (peristalsis); inhibits secretion, closes sphincters	Stimulates motility (peristalsis) and increases secretion of intestinal glands. Opens/relaxes the sphincters and is active in defecation.
Liver	Increases release of glucose (may produce stress related diabetes!)	
Urinary bladder		Contraction of detrusor muscle and relaxation of the internal urethral sphincter.
Sex Organs	Ejaculation in males	Erection of penis or clitoris
Hair	Erection (erector pilorum) "goose bumps"	

Note: in extreme terror both sympathetic and parasympathetic systems may become activated and thus although the sympathetic system must dominate, the sphincters of stomach, rectum and bladder may all open and heart rate may decrease.

Sympathetic Vs Parasympathetic Nervous System (Structurally)

COMPARISON OF SYMPATHETIC & PARASYMPATHETIC SYSTEMS (STRUCTURAL)		
	SYMPATHETIC	**PARASYMPATHETIC**
Alternative Name	Adrenergic system	Cholinergic system
General Effects	Fight, fright or flight; mobilisation of energy to cope with stress	Conservation and restoration of energy. *But during extreme situations of stress the parasympathetic system may be active*.
Extent Of Effect	Mass or widespread effect	Localised
Neurotransmitter At Ganglion And Organ Levels	All preganglionic fibres are cholinergic, (Acetylcholine, ACH) postganglionic mostly adrenergic, (Norepinephrine) except: sweat glands, vessels in skeletal muscles and penile vessels contain ACH and others.	All preganglionic are cholinergic, (Acetylcholine, ACH) and postganglionic mostly cholinergic but probably not all (others e.g. VIP, ATP)
Duration Of Effects	Long lasting	Brief
Outflow From CNS	Thoracolumbar (lateral horns of spinal cord from T1-L2 (L3)	Craniosacral (Brainstem nuclei of CNN III, VII, IX and X, & lateral horn cells of S2, S3, S4 segments of spinal cord via pelvic splanchnic

		nerves)
Location Of Ganglia	22-23 **paravertebral** ganglia of the sympathetic chain from the base of skull to the front of coccyx AND the **paravertebral** or **collateral** ganglia in relation to major branches of the abdominal aorta.	Terminal ganglia lie close to or within the wall of the target.
Fibres	Have **short** preganglionic (***white*** *ramus communicans*) and long postganglionic (***gray*** *ramus communicans*) fibres, with exceptions of splanchnic nerves (long preganglionic fibres).	Has long preganglionic and short postganglionic fibres

I The Parasympathetic Division Of The ANS: Craniosacral Outflow:

- CN III, VII, IX, X
- Spinal cord S2 to 4.
- Preganglionic parasympathetic: neurones in nuclei of brainstem
- Postganglionic parasympathetic: neurones located in peripheral ganglia near or within the structure being innervated.

a) Cranial Parasympathetic Nerves: CNIII, CNVII, CNIX AND CNX

Oculomotor N.: (details are not required. It is included here for completion).

- General Visceral efferents (GVE) type neurones, from Edinger Westphal nucleus, preganglionic fibres travel in the CN III to leave in the branch to the inferior oblique, pass to the ciliary ganglion, where they synapse and leave in the short ciliary nerve to pierce the sclera to supply the ciliary muscle and sphincter pupillae. Postganglionic fibres are thinly myelinated.
- Action: pupillary constriction (miosis), accommodation (focus on near object)

Facial N.:

- GVE neurones originate from superior salivatory and lacrimal nuclei in brainstem. Axons pass in nervus intermedius; Project to lacrimal gland via pterygopalatine ganglion and to **salivary glands** (**sublingual and submandibular**) via **submandibular ganglion**.
- Action: secretion of tears and saliva.

Glossopharyngeal N.:

- GVE neurones originate from inferior salivatory nucleus in brainstem. Axons travel in CN IX to **parotid gland** via the otic ganglion.
- Action: secretion of saliva.

Vagus N.:

- GVE neurones originate in Dorsal motor nucleus of Vagus and nucleus ambiguous and supply the thoracic and abdominal viscera.
- Action: reduce heart rate, bronchoconstriction, secretory and motor to glands and smooth muscle of stomach respectively, secretomotor to intestinal glands, excitatory to intestinal muscle coats, inhibitory to ileocecal and pyloric sphincters.

b) Sacral outflow: S2, S3, S4

- Anterior rami of 2nd, 3rd and often 4th sacral nerves issue **pelvic splanchnic nerves** to pelvic viscera. These fibres come from preganglionic neurones in the sacral parasympathetic nucleus.

- Action: motor to muscle of the rectum and bladder, but inhibitory to the vesical sphincter. Vasodilator to penile and clitoridic erectile tissue, probably vasodilator to testes and ovaries, and vasodilator and probably inhibitory to the uterine tubes and uterus.

II Sympathetic System: Thoracolumbar Outflow: T1-12, L1-2, (3) Spinal Cord

- Preganglionic sympathetic: neurones located in the intermediolateral cell column of spinal cord at the levels of T1-L2, (L3).
- **White ramus communicans** present only at the levels of T1-L2, (L3)
- **Gray ramus communicans** present at all vertebral levels.
- **Greater splanchnic nerve**: preganglionic sympathetic from T5 – T9
- **Lesser splanchnic nerve**: preganglionic sympathetic from T10 – T11
- **Least splanchnic nerve**: preganglionic sympathetic from T12 (least present!)
- Preganglionic axons may synapse with many postganglionic neurons for *the wide dissemination and perhaps amplification of sympathetic activity*, a characteristic not shared to the same degree by parasympathetic ganglia.
- Sympathetic ganglia include cells in:
  i) **Sympathetic trunk**: 3 cervical ganglia
  11-12 thoracic ganglia
  5 lumbar ganglia
  2 sacral ganglia and finally:
  the ganglion impar where the two sympathetic trunks meet in front of coccyx vertebra
  ii) **Prevertebral ganglia**: **Coeliac**, **Superior mesenteric**, **Aorticorenal** and **Inferior mesenteric ganglia** (surrounding the origin of major blood vessels from the abdominal aorta).
  iii) Scattered ganglia within autonomic plexuses that are not recognizable by naked eye
- Postganglionic sympathetic: neurones located in ganglia of sympathetic trunk or ganglia of midline autonomic plexuses (eg. around coeliac and mesenteric arteries).

The cervical part of the sympathetic trunk and ganglia

a) **Superior cervical ganglion**:
- related anteriorly to the internal carotid A., and posteriorly to the longus capitis muscle.
- probably formed from fusion of C1-4 ganglia.
- adjoins the second and third cervical vertebrae.
- sympathetic supply to eye, face, skin of head and neck, cerebral vessels, salivary glands, meninges of posterior cranial fossa and cardiac brr to heart.

b) **Middle cervical ganglion**:
- occasionally absent, may be fused with the superior ganglion
- located at the level of 6th cervical vertebra, anterior or superior to the inf. thyroid A.
- probably represents fusion of C5 and 6 ganglia.
- supplies upper limb, thyroid gland, parathyroid gland, heart, trachea and esophagus.

c) **Cervicothoracic (stellate) ganglion**:
- probably represents fusion of C7,8 and T1 ganglia. If T1 is separate there will be an inferior cervical ganglion.
- related posteriorly to longus colli muscle and neck of first rib.
- supplies heart, upper limb, lungs, thyroid gland.

Thoracic part of the sympathetic trunk and ganglia
- T1 ganglion usually fused to inf. cervical to make **cervicothoracic ganglion** (80% of cadavers).
- supplies heart (T1-4), Lungs (T4), abdomen (T5-12), upper limb (T2-9), lower limb (T9-12, L1,2).
- **Greater splanchnic nerve**: myelinated preganglionic efferent and visceral afferent fibres. Formed from branches of T5 to T9/10 ganglia. It supplies thoracic aorta, perforates the ipsilateral

crus of the diaphragm to supply mainly **coeliac** but also **aorticorenal ganglia** and also end in the suprarenal gland. Occasionally a splanchnic ganglion exists on the nerve opposite TV11/12.

- **Lesser splanchnic nerve**: carries preganglionic fibres that arise from sympathetic chain at T9 and 10 sympathetic ganglia, pierces the diaphragm with the greater splanchnic n. to end in aorticorenal ganglion.
- **Lowest (least) splanchnic nerve**: carries preganglionic fibres from T12, enters the abdomen with the sympathetic trunk to end in the renal plexus. Often not visible.

Lumbar part of the sympathetic trunk and ganglia

- 4 interconnected ganglia
- 4 lumbar splanchnic nerves arise and join **coeliac**, renal, **intermesenteric**, and **superior hypogastric ganglia**.
- supply abdominal, pelvic structures and obturator, internal and external iliac arteries.

Pelvic part of the sympathetic trunk and ganglia

- lies anterior to the sacrum.
- 4 or 5 interconnected ganglia
- trunks unite to form ganglion impar anterior to coccyx
- supply pelvic viscera. Sympathetic supply to leg arises in T10, 11, 12 and L1, 2 spinal cord but may synapse in lumbar or upper sacral ganglia.

III) The Plexuses of the Autonomic Nervous System:

There are 5 large autonomic plexuses with extensions, which pass along branches of large vessels.

Large Plexus	**Extensions**
Cardiac	left and right coronary plexuses atrial plexus
Pulmonary	nil
Coeliac	phrenic, splenic, hepatic, left gastric, intermesenteric, suprarenal, renal, testicular or ovarian, **superior mesenteric** and **inferior mesenteric**.
Superior Hypogastric	**left and right hypogastric "nerves"**, ureteric, testicular, ovarian, common iliac.
Inferior Hypogastric	middle rectal, vesical, prostatic, uterovaginal.

Central Control of ANS Activity

i) Medulla Oblongata and Pons: Reflex control of respiration and BP.

ii) Hypothalamus: receive visceral afferent impulses from brainstem, olfactory and limbic system, cortex of frontal lobe. Efferent impulses reach the reticular formation of brainstem, and neurones of intermediolateral column of spinal cord.

Referred Pain

Visceral pain related to special somatic areas, often felt away from the affected visceral organs. One of the examples is given below. With the help of your tutor and with colleagues consider a couple more of similar examples.

Eg. Pain of appendicitis is felt near umbilicus. This is an example of referred pain. The organs and the surrounding visceral pleura, pericardium or peritoneum are not supplied by somatic nerves, but receive the sensory fibres along with autonomic nerves from T9 and T10 segments of the spinal cord via lesser splanchnic nerves. Note that somatic nerves from T10 segment of the spinal cord supply the skin of the umbilical region and sympathetic nerves from the same segment (T10) of the thoracic spinal cord supply the appendix. The brain perceives the pain coming from T10 segment and hence patient a suffering from appendicitis initially complains of pain at the umbilical region.

Materials: Articulated skeleton; **Prosected specimens** of the deep head and neck, infratemporal fossa, pharynx, superficial and deep thorax, abdomen with celiac ganglion and plexus, deep abdomen with aorta and autonomic plexuses including superior hypogastric plexus, lateral pelvic wall with inferior hypogastric plexus; **Models** of cross section of spinal cord, (new) of infratemporal fossa, small larynx; **Accessory:** Anatomical chart of ANS.

APPENDIX 1
THE LYMPHATIC SYSTEM

Aims: To describe the organization of lymphatic system; to identify the role of lymphatic vessels and their drainage, lymph nodes and their areas of drainage; and the important lymphatic organs and their role in immune response of the body. In this appendix, you are being introduced to the organization distribution and method and the "hierarchy" of drainage of the lymphatic system. An introductory knowledge of the lymphatic system is very important to be aware of, before we discuss the lymphatic drainage of the organs of the various visceral systems. Lymphatic drainage of a diseased organ and the spread of the disease, sometimes decide the prognosis of a patient, a fine line between the present and future, and even determine the life expectancy of an individual.

The preliminary notes provided are to be used in conjunction with relevant labs.

1. To describe the organization of the lymphatic system.
2. To describe the lymph capillaries, lymph vessels and lymph nodes.
3. To describe distribution and patterns of lymphatic drainage of lymph nodes in the neck.
4. To describe Waldeyer's ring and the position of constituent lymphoid tonsils.
5. To describe the lymphatic drainage of the abdomen and thorax and the location of the cisterna chyli and the thoracic duct.
6. To state the functional significance of the lymphatic organs: tonsils, thymus and spleen.
7. To summarize the major functions of the lymphatic system.

The functions of Lymphatic System are varied:

- transport of tissue fluid formed in the capillary bed.
- the removal by mononuclear phagocytic series cells of cell debris and foreign matter (eg bacteria) and the prevention of bacterial and foreign material from entering the blood stream.
- production of lymphocytes and control of the immune responses.

Introduction and organization of lymphatic system:

The **lymphatic system** is a parallel and complementary system to the venous drainage of the body. It consists of lymphatic vessels and the lymphoid tissue. All organs and tissues of the body possess lymphatics and hence have a lymphatic drainage, ***except*** the CNS, bone marrow, inside of the muscles, and the avascular structures such as: hair, nails and hyaline cartilage. The lymphatic system forms the immune system of the body and serves as an essential defense of the body against bacteria and viruses.

Lymph is the tissue fluid that flows through the lymph vessel. Lymph is a clear watery fluid similar to plasma, containing proteins, white blood cells, with abundance of lymphocytes and a few red blood cells. The main functions of lymph include: part of the defense system of the body; control, contain and spread the infection from bacterial, viral and fungal agents; spread of cancer cells; return of excess fluid and proteins from tissue fluid to the blood stream; amongst others. Drainage of lymph is dependent on a few of the forces that help in propelling fluid through thin, vessels studded with multiple valves. These factors include: inspiration phase of respiration, the gravity, tissue pressure, muscle peripheral pump, low pressure in large veins and the pulsations of accompanying arteries.

The **lymphatic vessels (afferent and efferent)** are vascular tubes that facilitate the drainage of tissue fluid from the tissue spaces to the venous blood. The lymph vessels are provided with multiple bicuspid valves that determine the direction of flow of fluid from the periphery to the centre (towards the heart, in this case, major veins of the neck). The lymph vessels begin as a lymph capillary network in the periphery, for example, in the subcutaneous tissues on the dorsum of hand and foot. The lymph capillaries are thinner than blood capillaries and are permeable to foreign particles. The ascending lymph vessels that carry lymph to a lymph node are **afferent** and those that carry the lymph away from the node are **efferent** vessels.

Lymphatic capillaries form plexuses in tissue spaces, which have much wider meshes than those of adjacent blood capillaries. They often begin as dilated lymphatics with blind endings. The endothelium of lymphatic capillaries is permeable to much larger molecules than blood capillaries, as well as cell debris, bacteria and colloidal material.

Lymph drained from most tissues is clear and colorless, but from the small intestine it is milky due to the absorption of fat globules (chylomicrons) and is called chyle. The terminal lymph capillaries from this region are called lacteals. Lymphatic capillaries are absent from avascular structures (eg epidermis, cornea, articular cartilage) and from the central nervous system and bone marrow. Lymphatic capillaries join into larger vessels, which pass to local lymph nodes. These are arranged largely in regional groups. There are occasional exceptions to this e.g. the lymph vessels of the thyroid gland, esophagus, coronary and triangular ligaments of the liver (to be discussed later in this course) drain directly into the thoracic duct without passing through regional nodes.

Since lymphatic vessels are usually associated with arteries and veins during development, it is often found that the deep lymphatic channels (trunks) in the adult accompany the blood vessels.

Several factors **aid** the flow of lymph fluid from tissue spaces to lymph nodes and finally to the venous bloodstream:

- 'filtration pressure' in tissue spaces, generated by filtration of fluid under pressure from the haemal capillaries.
- contraction of neighboring muscles compresses the lymph vessels, moving lymph in the direction determined by the arrangement of valves.
- pulsation of adjacent arteries.
- respiratory movements and the low blood pressure in the brachiocephalic v. during inspiration.
- smooth muscle in the walls of lymphatic trunks is most marked proximal to their valves. Stimulation of sympathetic nerves accompanying them causes their contraction. Pulsatile contractions in the thoracic duct are also known to occur.

The **lymphoid tissue** is a type of connective tissue that contains circulating lymphocytes and aggregates of lymphocytes & their associated cells. Lymphoid tissue may be intimately associated with the lymphatic vessels, eg chains of lymph nodes along the lymphatic vessels; or may be unconnected with lymphatic channels, eg the spleen, bone marrow and thymus. It can be organized in the form of: tonsils, lymph nodes, and lymphatic nodules.

The **Lymph Nodes**

The microscopic structure of lymph nodes may already be dealt with in Basic and Systematic Histology and is irrelevant here. There are, however, several important **roles** performed by lymph nodes which we need to consider:

- provision of a labyrinth of channels of large surface area and volume through which lymph slowly percolates.
- trapping of foreign material in lymph nodes and exposure to nodal macrophages.

- production of lymphocytes and a pool of stem cells to become antibody-producing B lymphocytes and mature T lymphocytes.
- interaction between antigen-bearing mononuclear phagocytes and lymphocytes to produce immune responses.
- re-entry of blood-borne lymphocytes into lymphatic channels and thence to the haemal circulation.
- humoral antibody production, its addition to lymph and ultimately the blood.

A normal young adult body contains about 400 to 450 lymph nodes. The limbs and superficial body wall have relatively few lymph nodes. The arm and superficial thoraco-abdominal wall (down to the umbilicus) contain about 30 nodes. The leg, superficial buttock, infraumbilical abdominal wall and perineum contain only about 20 nodes. The head and neck carry about 60 to 70 nodes, while the remaining nodes are divided between the thorax (up to 100 nodes in deep walls and contents) and abdomen and pelvis (230 or more nodes in deep walls and contents).

Lymphatic drainage of the body:

Lymphatic drainage of the head and neck:

Nodes in the head and neck may be divided into a terminal group related to the carotid sheath (**deep cervical nodes**), and **superficial cervical nodes**. The deep cervical nodes drain into right and left **jugular lymph trunks**, which enter the **thoracic duct** or the junction of internal jugular vein and subclavian vein on the left and the **right lymphatic duct** or at the junction of internal jugular vein and subclavian vein on the right.

i) The **deep cervical lymph nodes** are divided into **superior** and **inferior** groups. The superior group called the **jugulodigastric** nodes lie adjacent to the upper part of internal jugular vein usually deep to the sternomastoid muscle. The inferior group called the **juguloomohyoid** nodes lies adjacent to the lower part of internal jugular v.

ii) **Superficial** groups:

- in the head and face: **occipital**, **retroauricular** (mastoid), **parotid**, **buccal** (facial).
- in the neck: **submandibular**, **submental**, **anterior cervical**, **superficial cervical**.

Note: Efferents from these nodes drain to the deep group.

iii) **The Tonsils and Waldeyer's Ring:**

Note the **palatine**, **tubal**, **lingual** and **pharyngeal tonsils** form a *Waldeyer's ring*. These collections of the lymphoid tissues form the first line of defense against the pathogens entering via nasal and oral cavities.

To summarise: note that the lymph from the right head, neck and face is drained by the **right jugular trunk**; from the right upper limb is drained by the **right subclavian trunk**; and from the right side of the chest including the upper surface of the right half of the diaphragm is drained by the **right bronchomediastinal trunk**. These trunks may individually drain into the venous circulation at the junction of right internal jugular vein and the right subclavian vein. In approximately 20% of population, these join together and form a single channel called the **right lymphatic duct**, which drains at the junction of right internal jugular and right subclavian vein.

Lymphatic drainage of the thorax:

Thoracic wall: Lymph vessels from the thoracic wall and deeper tissues drain into 3 groups of *parietal* nodes:

- **Diaphragmatic:** also receives lymph from liver.
- **Parasternal:** lie along the internal thoracic vessels and also receive lymphatics from: breast (medial part). The efferents from these nodes drain into **tracheobroncheal** nodes and form the **right** and **left bronchomediastinal trunks**.

- **Intercostal:** lie on the posterior part of the intercostal space and drain lymph from the deeper part of the chest wall.

Visceral nodes: all the lymph from the thoracic viscera drains into regional nodes and the efferents then drain into the **right and left bronchmediastinal trunks**. The regional lymph nodes are:

- **pulmonary**
- **bronchopulmonary**
- **tracheobronchial (superior and inferior)**
- **paratracheal**
- **mediastinal**

Lymphatic drainage of lungs and bronchi: The lymphatics form two pulmonary plexuses:

Superficial pulmonary plexus drains tissues of the lung and visceral pleura; and **deep pulmonary plexus** drains bronchi. Efferents from these plexuses drain into **pulmonary** lymph nodes and the **bronchpulmonary** lymph nodes. The pulmonary and bronchopulmonary lymph nodes drain into tracheobroncheal lymph nodes that lie at the bifurcation of trachea. *Note: enlargement of tracheobroncheal lymph nodes can cause deviation of carina from midline*. The efferents then form the right and left bronchmediastinal trunks.

Lt and **Rt bronchomediastinal trunks** drain into the **thoracic duct** and the **right lymphatic duct** respectively.

Lymphatic drainage of the Abdomen:

General consideration: The lymph drainage of the abdomen is mainly via **thoracic duct**. Three terminal groups of lumbar nodes are identified:

i) **Preaortic**, consisting of:

- **coeliac** nodes, draining gastric, hepatic, pancreaticosplenic nodes
- **superior mesenteric** nodes, draining nodes in the mesenteries
- **inferior mesenteric** nodes, draining nodes in the mesenteries.

These are associated with the corresponding artery. Efferents from these nodes form **intestinal trunks**, which enter the abdominal confluence of the lymph trunks called the **cisterna chyli** and then the **thoracic duct**.

ii) **Lateral aortic** or **paraaortic**, efferents of which form paired lumbar trunks. Lymphatic vessels from the kidney, suprarenal glands, abdominal ureter, posterior abdominal wall, testis and ovary, uterus and uterine tube all drain directly to the lateral aortic nodes. These nodes also ultimately drain the lower limb. Several other named groups of nodes are known:

- **common iliac** nodes
- **external iliac** nodes
- **internal iliac** nodes

iii) **Retroaortic** nodes drain posterior abdominal wall. They may actually be peripheral nodes of the lateral group.

Stomach: four main groups of lymph nodes are responsible for draining the stomach:

- **Left gastric**: along the left gastric artery and drain the body and lesser curvature of stomach.
- **Right gastroepiploic**: drain part of the right part of the greater curvature of stomach. Efferents from these nodes drains into **pyloric** nodes that lie on the head of pancreas.

- **Left gastroepiploic**: lymph nodes lie along the artery and drain the left half of the greater curvature and fundus of the stomach. The efferents from these nodes drain into **pancreaticosplenic** nodes that lie along the splenic artery.
- Right gastric nodes: drain part of the lesser curvature and the pyloric part of the stomach.

Efferents from the four groups drain into the **coeliac** nodes that lie along the origin of coeliac trunk. Cancer of stomach may require removal of these nodes and the surrounding structures. **Lymphatic drainage of gall bladder and biliary system:** the lymph vessels draining the cystic duct, hepatic ducts and the proximal part of bile duct drain into **cystic node**. Cystic node is commonly enlarged in cholecystitis and most constantly is located in the angle between cystic duct and the common hepatic duct at the formation of bile duct. The lower part of bile duct drains into **hepatic** and **pancreaticosplenic** lymph nodes.

Pancreas: lymph drains into **pancreaticosplenic** and **pyloric** lymph nodes.

Liver & Gall Bladder: lymph drains into hepatic nodes and then into coeliac nodes surrounding the origin of coeliac trunk. **Hepatic lymphatics:** can be divided into superficial and deep groups. The superficial group of lymphatic vessels run on the surface of the liver may drain across the diaphragm to the **internal thoracic** (mammary) and **diaphragmatic** lymph nodes to the **Rt lymphatic duct**, and/or thoracic duct directly; the deep lymphatics lie close to IVC may terminate into the **hepatic** and **gastric** nodes in the abdomen and thence to the **coeliac** nodes and ultimately the **thoracic duct**.

Lymphatic drainage of small and large intestine:

The lymph drainage of the small and large intestine is via mainly the **thoracic duct**.

Small intestine: the lymphatic vessels accompany the branches of the superior mesenteric artery and drain into nodes in the mesentery. The lymphatic vessels draining the small intestine called the **lacteals** carry the lymph as well as the fat globules and other absorbed material from the intestines.

Duodenum: lymph vessels accompany the arteries that supply the duodenum and drain into **coeliac** and **superior mesenteric** lymph nodes.

Jejunun and ileum: The lymph primarily drains into the peripheral group lying close to the wall of the intestine, which drain into the jejunal and ileal groups lying close to the arcades, which finally drain into the **superior mesenteric nodes** (7-11), lying around the origin of superior mesenteric artery.

Large intestine: four main groups of lymph nodes are seen:

- **Epicolic**: on the walls of the colon;
- **Paracolic**: on the inner margin of the colon;
- **Intermediate** group: along the branches of inferior mesenteric artery viz. Middle colic, sigmoidal and superior rectal and finally the
- **Central or terminal** called the **inferior mesenteric** nodes, lying around the origin of inferior mesenteric artery.

Efferents from the superior and inferior mesenteric nodes form **intestinal trunks**, which along with lumbar trunks enter the abdominal confluence of the lymph trunks at the level of L1-L2, called the **cisterna chyli** and then ascend as the **thoracic duct**.

Lymphatic drainage of the Pelvic viscera:

Lymph from the pelvic viscera drains primarily into internal iliac, external iliac and sacral lymph nodes. The efferents from these nodes drain into common iliac group and the lumbar nodes (see above).

Uterus and cervix: lymphatics from the uterus and cervix drain laterally to its lateral wall and then the lymphatics take four main routes:

- Those traveling through the parametrium drain into **external** and **internal iliac** lymph nodes.
- Traveling from close to the uterine tubes accompany the ovarian artery and drain into **paraaortic** lymph nodes.
- Traveling from the posterior surface of the uterus and cervix follow the uterosacral ligaments and drain into **sacral** lymph nodes.
- Lymphatics that are related to the round ligament of uterus follow the ligament into the inguinal canal and drain into the **superficial inguinal** lymph nodes.

Ovaries and uterine tube: the lymph from the uterine tubes and ovaries drains into **internal, external, common iliac**; and **lumbar** nodes.

Male genital organs:

Testes: the lymphatic vessels accompany the ductus deferens and drain into **lumbar** nodes.

Scrotum: lymph flows into **superficial inguinal** lymph nodes.

Penis: The skin of penis drains into **superficial inguinal** lymph nodes; while the glans, corpus spongiosum and corpora cavernosa along with the spongy urethra drain into **deep inguinal** lymph nodes.

Prostate and seminal vesicles: drain into **iliac** lymph nodes and efferents then drain into **lumbar** nodes.

Sentinel or supraclavicular lymph nodes:

The supraclavicular lymph nodes are sometimes enlarged when there is a reflux of lymph from the excessive drainage from thoracic and abdominal viscera. *Note: one must suspect cancer of thoracic or abdominal organs*.

The Thymus

The thymus is responsible for the production of thymus-processed or T-lymphocytes. It also has humoral secretory functions (producing thymulin, thymopoietin, thymosin alpha I and thymosin beta 4), which regulate lymphocyte production, differentiation and activities within the thymus as well as throughout the body's lymphoid tissue. Thus, it may be regarded as an endocrine organ.

At birth it weighs about 10 to 15 g, growing until puberty when it weighs 30 to 40 g. After puberty it gradually diminishes in size, being replaced by fatty tissue, and weighs only about 10 g during middle age.

In early life it consists of two unequal pyramidal lobes connected by loose connective tissue. It lies in the *superior* and *anterior mediastinum*, extending inferiorly as far as the 4th costal cartilage and superiorly tapering into the neck as far as the inferior poles of the thyroid.

The Spleen

Much of splenic anatomy is dealt with gross anatomy of the viscera in the abdomen. However, we can discuss a few general points here.

The spleen lies in the left hypochondrium (region below the left ribs), to the left of the fundus of stomach. It consists of a capsule surrounding white and red pulp. The red pulp contains sinuses filled with blood, while the white pulp consists of lymphoid tissue: reticular fibres, lymphocytes (both T and B). The spleen is involved in phagocytosis of foreign debris in the blood, immune responses, haemopoiesis and erythrocyte storage (more in other mammals, not humans).

Although it is of great importance in the defense of the body, it is not absolutely essential, in that many of its functions may be taken over by other lymphoid tissue or the liver if the spleen is removed.

Major lymphatic channels in the body (see accompanying diagrams):

1) **Thoracic Duct and Cisterna Chyli:**

This is the largest lymphatic channel in the body (38 - 45 cm in length) and extends from the 1st lumbar vertebra to the root of the neck.

It drains lymph from the left arm, left neck and head, left thorax, left upper abdomen up to the level of umbilicus, both sides of the abdomen below the umbilicus and both lower limbs.

It arises either from the confluence of several lymph channels on the posterior abdominal wall, or in some individuals these lymph channels drain into a dilated sac known as the **cisterna chyli**, which lies anterior to the bodies of 1st and 2nd lumbar vertebrae.

The thoracic duct then passes through the aortic opening in the diaphragm (TV 12), ascends in the posterior mediastinum to the right of the midline between the descending aorta (to its left) and the azygos vein (to its right).

When it reaches the level of the TV5 it inclines to the left until it finally terminates either into the junction of the left internal jugular and subclavian Vs or one of those veins only. In 50% of people it has a terminal dilatation or **ampulla**. Before it terminates it receives the Lt jugular (draining lymph from left head and neck) and Lt subclavian (from left arm) trunks.

The thoracic duct drains lymph from the entire body except the right head, neck, face, upper limb, and right side of the thoracic cavity.

2) **Right Lymphatic duct**

On the right side of the body, lymph from the right head and neck, right arm, and right thorax and abdomen (down to the convex surface of the liver) are drained by the Rt jugular, Rt subclavian and Rt bronchomediastinal trunks respectively. In 20 % of people these join into a single channel, the Rt lymphatic duct, which drains into the junction of the Lt internal jugular and Lt subclavian vv or each of these veins separately.

TUTORIAL/LABORATORY CLASS 2

THE UPPER RESPIRATORY TRACT: NOSE, NASAL CAVITY, AIR SINUSES, LARYNX AND THYROID GLAND

Aims: To know the structure and functions of the larynx and the role of palatal, tongue and lip musculature in phonation and speech; Gross anatomy of Thyroid gland.

Specific objectives

1. To identify the external nose, the nasal cavity and the paranasal sinuses.
2. To identify the hyoid bone and the cricoid, thyroid, epiglottis and arytenoids cartilages and their articulations and summarise their movements.
3. To identify the vocal, vestibular and aryepiglottic folds, ventricles and conus elasticus of the larynx.
4. To state the motor and sensory innervation of the larynx.
5. To identify main features of the trachea and its gross anatomical relationship.
6. To identify the thyroid gland, its blood and nerve supply.
7. To deduce the roles of the larynx, tongue, palatal and lip musculature in speech.

Learning Activities

1. On the prosected specimens and the nose model identify the **external nose** including the bony part formed by the paired **nasal** bones and cartilaginous part formed by paired **lateral** and **major alar** cartilages, single **septal cartilage** that divides the nasal cavity in two halves, and a few **minor alar** cartilages.
2. Identify the openings of the nasal cavity viz. **anterior** and **posterior (choanae) nares**, sensory nerve supply of the external nose and the nerve supply to the nasal musculature.
3. Identify the walls of the nasal cavity, the bony and/or cartilaginous components of the **roof**, **floor**, **nasal septum** (medial wall) and **lateral wall** of the nose.

4. To identify the **conchae (superior, middle and inferior concha)**, **meatii** (the **superior, middle and inferior meatus**: space between the concha and the lateral wall of the nose) and **sphenoethmoidal recess** of the nasal cavity. Identify **ethmoidal bulla**, **hiatus semilunaris** and **infundibulum** in the middle meatus.
5. To locate the regions of the nasal cavity: **vestibule**, **atrium**, and the **olfactory** and **respiratory** regions. Discuss the importance and functions of these regions.
6. To identify **paranasal sinuses** and their openings. Observe a demonstration of **frontal** and **sphenoidal** air sinuses, **ethmoidal air cells** and the **maxillary antrum**. *What is the function of these air sinuses and where do these sinuses drain? What structure drains into the inferior meatus? Which air sinus is most prone to infection and why? Discuss to what areas the infection from nasal cavity can spread?*
7. To describe the blood and nerve supply of the nose and paranasal sinuses.
8. Describe the blood and nerve supply to external **nose** and **nasal cavity**. Blood supply is derived from: maxillary artery and anterior and posterior ethmoidal arteries, branches of ophthalmic artery. The nerve supply is from the nasopalatine n., a branch of CNV_2; nasociliary n, branch of CNV_1; and branches of sympathetic and parasympathetic nerves.
9. Identify the **larynx**: and note that the skeleton of larynx is formed by the **hyoid** bone and the **thyroid, cricoid, epiglottis, arytenoid, corniculate and cuneiform cartilages**. Describe the structure of the major cartilages of the larynx.
10. Identify the **laryngeal joints** and **ligaments/membranes of the larynx**. On the prosected specimens and models of larynx identify the extrinsic ligaments: **thyrohyoid membrane** and **hyoepiglottic ligament**. Also identify the intrinsic ligaments: **cricothyroid ligament** (**cricovocal membrane** or **conus elasticus**, **vocal ligament** and **median cricothyroid ligament**)
11. Identify the **laryngeal cavity** and its **regions**. On the prosected specimens and models note the internal features of the larynx. The laryngeal cavity is divided from superior to inferior into three regions: **vestibule**, **ventricle** and the **infraglottic cavity**. On models and wet specimens identify the **internal features of the larynx**.
12. Identify the **intrinsic muscles** of the larynx, note their attachmentsand deduce their actions. Note that they can be divided into two groups: identify the **mm of laryngeal inlet**: **aryepiglotticus**, **oblique arytenoideus** and **transverse arytenoideus** muscles; identify the **mm of the vocal folds**: **lateral cricoarytenoid**, **posterior cricoarytenoid**, **cricothyroid**, and **thyroarytenoid** muscles. Discuss the action of these muscles.
13. Discuss the nerve supply to the laryngeal muscles and the sensory and autonomic innervation of the laryngeal mucosa.
14. Discuss the **blood supply and sensory innervation to the larynx**.
15. Discuss the **function of larynx** in breathing and phonation.
16. Examine the articulated model of larynx and deduce the shape of the **rima glottides** during phonation, full inspiration, coughing and whispering. Deduce the probable action of the cricothyroid muscle and the results of a lesion of (i) the recurrent laryngeal nerve and (ii) the internal laryngeal nerve.
17. On the specimens and models, follow the course of the **vagus nerve** and identify its branches that are concerned with laryngeal innervation. Identify the **superior laryngeal nerve,** which divides into the **internal laryngeal nerve** (sensory) piercing the thyrohyoid membrane, and the **external laryngeal nerve** (motor) going to the cricothyroid muscle. Locate the **recurrent laryngeal nerve** (sensory & motor) in the groove between the trachea and the esophagus. Note the different course and relationships of the right and left recurrent laryngeal nn. *What nerve is vulnerable to injury in the piriform recess and why?*
18. Identify the blood supply of the **thyroid gland**, (**superior and inferior thyroid arteries)** and nerve supply. Discuss the relations and function of the thyroid gland. Observe a demonstration of the trachea and thyroid gland. Examine prosected specimens and identify the **lateral lobes**,

isthmus and **pyramidal lobe** (present in 40% of people) of the thyroid gland, **superior** and **inferior thyroid arteries**. Identify the superior, middle and inferior thyroid veins. Note the relationship of the thyroid gland to the visceral tubes and recurrent laryngeal nerves. The lateral aspect of thyroid gland is covered by the sternothyroid muscle. The posterior border is related to the **parathyroid glands** (2 each side). Identify the **relations of the thyroid gland**: **anterior:** sternothyroid and sternohyoid muscles; **lateral:** carotid sheath and its contents (internal jugular vein and vagus nerve; superior root of the ansa cervicalis is embedded in its anterior wall); and **posterior**: larynx, pharynx, esophagus.

19. *During physical examination, the patient is asked to swallow and the examiner observes and palpates the thyroid gland. What is the anatomical basis of this maneuver? Discuss the likely causes and effects of damage to the recurrent laryngeal nerve. Why do some patients suffer voice change/loss after thyroid surgery?*
20. Discuss the role/functions of nasal cavity, paranasal sinuses and larynx in breathing and speech.
21. Discuss the **clinical problems 2, 5 and 6.**

Lecture Notes:

1. <u>Nose, Nasal Cavity and Paranasal Sinuses:</u>

External Nose:

The Dorsum of the nose: This is the prominent bridge between the right and left sides of the nose. The upper end of the dorsum is the root or bridge and the lower end of the dorsum is the tip.

The Anterior nares: Each nostril or the external nasal aperture is bounded laterally by an ala and medially by a nasal septum.

"Piriform Aperture": This is a pear shaped hole in the dried skull and is bounded by frontal processes of maxillae and a pair of nasal bones. The cartilaginous part of the nose is attached to the piriform aperture.

Post nares or "choanae": Each choana is bounded:

Inferiorly: by the horizontal plates of palatine.

Laterally: by the medial pterygoid plates.

Medially: by the nasal septum (vomer).

Superiorly: by the body of the sphenoid covered by (ala of) vomer.

Skeleton of the Nose:

Upper immovable part: bony: formed by a pair of nasal bones, the frontal processes maxillae and the fronto-nasal suture.

Lower movable part: cartilaginous: Made of hyaline cartilage. There are 5 large cartilages: lateral nasal (two), major alar (two) and septal (single) and few smaller cartilages, the minor alar.

Nerve supply of the external nose:

<u>Motor</u>: The muscles of nose, (you need not identify them), are supplied by branches of facial (CN VII).

<u>Sensory</u>: General sensations to the nose are supplied by: **CNV_1** (via external nasal & infratrochlear branches of nasociliary n.) and also **CNV_2** (via infraorbital branch).

<u>Nasal Cavities:</u> The nasal cavity is divided into a right and a left half.

<u>Boundaries:</u> Each half of the nasal cavity has a roof, floor, lateral and a medial wall. The medial wall is also called the **nasal septum** and is common wall between the two nasal cavities.

<u>Roof</u>: is contributed by frontal, lacrimal, ethmoid (cribriform plate) and sphenoid (body) covered by vomer and palatine bones.

Floor: is contributed by palatine processes of maxillae and horizontal plates of palatine bones. It is called the **hard palate**, and is wider than roof, concave from side to side, is smooth and horizontal.

Medial wall: or **nasal septum** is the common wall to the nasal cavities and is made by septal cartilage anteriorly, perpendicular plate of ethmoid superiorly and vomer posteriorly.

Lateral wall: is formed by nasal, maxilla, lacrimal, ethmoid (labyrinth, superior & middle concha), inferior nasal concha, palatine (perpendicular plate) bones.

Conchae Meatii and Openings of the Paranasal Sinuses:

Conchae and meatii: Within the nasal cavity projecting from the lateral wall are three bony shelves, which protrude into the nasal cavity. These are called **superior, middle** and **inferior concha**. The superior and middle conchae are parts of ethmoid and inferior concha is a bone by itself. The conchae are covered by mucus membrane and thus increase the surface area of mucus membrane for respiratory functions. Under each concha is a space, which is called **meatus**. Thus there is **superior meatus** under superior concha, **middle meatus** under middle concha and **inferior meatus** under inferior concha. Superior to the superior concha is a space called **sphenoethmoidal recess**.

Openings and drainage of Paranasal Sinuses:

The *sphenoethmoidal recess* above superior concha receives the opening of sphenoidal air sinuses.

The *superior meatus* under the superior concha receives the opening of posterior ethmoidal air cells.

The *middle meatus* lies inferior to middle concha and contains a raised region called the **ethmoidal bulla**, which receives the openings of, anterior and middle ethmoidal air cells. Under the bulla is a grooved half moon shaped region called the **hiatus semilunaris,** which becomes funnel shaped superiorly, and is called the **infundibulum**. The hiatus semilunaris receives the opening of maxillary sinus posteriorly and the infundibulum receives the opening of frontal air sinus via **frontonasal duct**.

The *inferior meatus* receives the opening of nasolacrimal duct.

Regions of the Nasal Cavity:

The nasal cavity can be divided into following regions.

- **Vestibule and atrium**:

  Vestibule: Is a slight dilatation inside opening of each nostril. It is lined by skin, hair, with sweat and sebaceous glands. It is located inside the nostril and in line with inferior meatus.

  Atrium: is the area above vestibule and in line with middle meatus lined by middle membrane.

- **Respiratory region**:

  The respiratory region is lined by mucus membrane and it is highly vascular. The mucus membrane is thrown into several folds in the region of conchae and meatii to increase surface area. It functions to moisten and warm the air. Anterior 1/3rd of this region is less active, and posterior 2/3rd is an area of active ciliary motion and thus rapid drainage takes place downwards and backwards into nasopharynx.

- **Olfactory region**:

  It is bounded by superior concha and upper 1/3rd of nasal septum. It is lined by specialised mucus membrane (yellowish in color in the living) containing ganglion cells (neuroepithelium), which give rise to the bundles of nerve fibres called the olfactory nerves. The olfactory nerves, as 18-20 filaments then pierce the cribriform plate and enter into olfactory bulb, which continues as the olfactory tract.

Nerve Supply of the Nasal Cavity:

General sensory: ophthalmic CNV_1 and maxillary CNV_2.

(i) Nerves to anterior part of nasal cavity: from anterior ethmoidal branch off ophthalmic nerve (CNV_1).

(ii) Nerves to larger post part: from nasal, nasopalatine, and palatine branches of pterygopalatine ganglion, which are postganglionic parasympathetic nerves derived from maxillary (CNV_2) and Facial (CNVII).

Autonomic nerve supply:

Sympathetic: The preganglionic fibres arise from T1 level of the spinal cord, reach superior cervical ganglion and synapse. The postganglionic fibres form a plexus on the internal carotid artery, which gives rise to the *deep petrosal nerve*, eventually becomes *nerve of pterygoid canal* and passes through the pterygopalatine ganglion. These fibres produce **vasoconstriction** and thus **dryness** of nasal mucosa.

Parasympathetic: The preganglionic parasympathetic fibres arise as *greater petrosal nerve* carrying preganglionic parasympathetic fibres from CNVII. The greater petrosal nerve joins with the *deep petrosal nerve* and forms *nerve of pterygoid canal*. It reaches the pterygopalatine ganglion where the preganglionic parasympathetic fibres in greater petrosal nerve synapse and postganglionic fibres are distributed as nasal branches, nasopalatine branches, palatine branches (the greater and lesser palatine nerves) and pharyngeal branches. The parasympathetic nerves produce **vasodilation** and **secretomotor effect** and thus a running nose.

Blood Supply and Lymphatic drainage of the Nasal Cavity:

The blood supply is derived from the branches of **maxillary**, **ophthalmic** and **facial arteries**

Little's area: Is an area of anastomosis between facial and maxillary arteries, (often anterior ethmoidal branch of ophthalmic artery contributes into the anastomosis as well). An abrasion or injury to the area leads to heavy bleeding (epistaxis). The bleeding could be potentially fatal in little infants and adults particularly in hypertensive patients. Sometimes ligation of the external carotid artery is often the only treatment.

Lymphatics from the nasal cavities drain into deep cervical lymph nodes.

The Paranasal Sinuses:

The paranasal sinuses are cavities in the enclosed in compact bone and lined with endosteum, and is fused with the mucus membrane. The paranasal sinuses are present in the frontal, ethmoidal, sphenoidal and maxillary bones. They are diverticulations of the cavity of nose and are filled with air. The mucus membrane is ciliated epithelium, (pseudostratified columnar), lines the nasal sinus and is continuous with that of nasal cavity. The sinuses are relatively larger in males than in females. They may be absent or very small at birth; but the ethmoidal and maxillary sinuses are usually present at birth. Anterior ethmoidal gives rise to frontal, and post ethmoidal and maxillary sinus gives rise to sphenoid. The air sinuses enlarge up to puberty and thus account for cracking (breaking) of voice in boys. They enlarge again in old age due to absorption of bones of the diploe and thus result in the deep, resonant voice of old age.

Functions:

- to make bones bigger without increasing their weight,
- to increase surface area of mucous membrane,
- act as resonating chambers for voice.

Drainage of sinuses:

Drainage takes place by ciliary motion and with gravity and also by suction during blowing of nose.

The maxillary sinus (antrum) has a very high opening in the middle meatus, thus it is easy to fill but very hard to drain.

Nerve supply (sensory and secretomotor) of paranasal sinuses:

Sensory: Branches of CNV_1 and CNV_2 and

CNV_1: supplies frontal, ethmoidal and sphenoidal air sinuses,

CNV_2: supplies maxillary and sphenoidal air sinuses.

Secretomotor: Nasal and nasopalatine branches of pterygopalatine ganglion.

2. **Larynx**:

The **larynx** extends from the tongue to the trachea. In adult males it lies in level with the 3rd to 6th cervical vertebrae. Note its relations as follows:

i) anterior: thyroid gland isthmus, infrahyoid muscles.

ii) lateral: carotid sheath and contents, infrahyoid mm, sternomastoid muscle and the thyroid gland.

iii) posterior: laryngopharynx, prevertebral mm, prevertebral layer of fascia and the vertebral bodies.

The "Skeleton" Of Larynx: includes following *cartilages* and their associated *membranes* and *ligaments*:

The **thyroid cartilage** consists of two quadrilateral laminae, their anterior borders fused to form the **laryngeal prominence** (Adam's apple). The laminae are separated above by a V-shaped **superior thyroid incisure or notch**. The posterior borders of the laminae are prolonged as the **superior and inferior cornua**.

The **cricoid cartilage** is shaped like a signet ring and has quadrate **posterior laminae** and a narrow **anterior arch**. It articulates with the inferior cornua of the thyroid cartilage. An **anterior (median) cricothyroid ligament** connects adjacent margins of the cricoid and thyroid cartilages.

The paired **arytenoid cartilages** are pyramidal in shape, with three surfaces, a **base** and an **apex**. The base has a **muscular process** laterally and a **vocal process** at its anterior angle.

The **apex** articulates with the **corniculate cartilage**, which lies posteriorly in the aryepiglottic mucosal folds.

The **cuneiform cartilages** are club like elastic fibro cartilages, which lie in the aryepiglottic folds, anterosuperior to the corniculate cartilage.

The single **epiglottic cartilage** or the **epiglottis** projects behind the tongue and in front of the laryngeal inlet. Its sides are attached to the arytenoid cartilages by the aryepiglottic folds. Its free rounded end is joined to the thyroid cartilage by a **thyro-epiglottic ligament**. **Median glosso-epiglottic** and **lateral gloss-epiglottic folds** connect the anterior surface of the epiglottis to the back of the tongue and the lateral pharyngeal wall respectively.

Identify the major **laryngeal joints and ligaments**:

- The **cricothyroid joint**, between cricoid and inferior cornua of thyroid cartilage, and the
- **cricoarytenoid joint**, strengthened by a capsular ligament and a strong **posterior cricoarytenoid ligament**.
- Extrinsic ligaments include the **thyrohyoid membrane** attached to the cranial border of the thyroid cartilage below and to the superior margin of the posterior surface of the hyoid bone above. The **hyoepiglottic ligament** attaches the epiglottis to the hyoid bone.
- Intrinsic ligaments include the **cricothyroid ligament** (cricovocal membrane). The thickened superior edges of the cricothyroid ligament complex (**vocal ligaments**) extend from the apices of the arytenoid vocal processes to the dorsal aspect of the thyroid angle at about its midpoint and form the basis of the **vocal folds**.

The **Laryngeal Cavity** and **internal features** of larynx**:**

The **laryngeal cavity** extends from the **laryngeal inlet (aditus laryngis)** to the lower

border of the cricoid cartilage.

The **regions of the laryngeal cavity**:

- **vestibule,**
- **ventricle** and
- **infraglottic cavity**; and the muscles: **cricothyroid, posterior cricoarytenoid and aryepiglottic**.
- The laryngeal inlet is bound anteriorly by the upper edge of the epiglottis, posteriorly by the mucosa between the arytenoids on each side (**interarytenoid fold**) and laterally by the aryepiglottic folds. The **aryepiglottic folds** have oval anterosuperior and posteroinferior swellings (**cuneiform and corniculate tubercles**) due to the cuneiform and corniculate cartilages respectively.
- Paired folds of mucosa (**vestibular and vocal folds**) partially divide it into a **laryngeal vestibule**, above the vestibular folds; a **middle part** between the vestibular and vocal folds is called the **ventricle**; and a **lower part** extending from the vocal folds to the lower border of the cricoid is called the **infraglottic cavity**.
- The vestibular folds raised by the vestibular ligament have a fissure between them known as the **rima vestibuli**. Similarly, the vocal folds have a fissure between them known as the **rima glottidis or glottis**. The rima glottidis is limited posteriorly by the mucosa passing between the arytenoid cartilages. Between the vocal folds is the **intermembranous part** of the glottis, while between the arytenoids is the **intercartilaginous part**.
- The **laryngeal sinus** or the **ventricle** lies between the vocal and vestibular folds laterally. Anteriorly the sinus opens into a **laryngeal saccule,** which ascends between the vestibular ligament and the thyroid cartilage.

Muscles of the Larynx:

The **intrinsic laryngeal musculature**, can be divided into 2 groups:

The muscles of the laryngeal inlet (sphincters):

1. **Aryepiglottic** muscle: from epiglottis to arytenoid cartilages,
2. **Oblique arytenoid** muscle: continuation of aryepiglottic muscle, passing to opposite side,
3. **Transverse arytenoid** (single muscle): bridges the gap between the two arytenoids, deep to the obliques.

The muscles of the vocal folds:

1. **Lateral cricoarytenoid** muscle (*adductor*): from the upper border of the cricoid arch to the front of the arytenoid muscular process of the same side,
2. **Posterior cricoarytenoid** muscle (*abductor*): from posterior surface of the cricoid lamina to the back of the arytenoid muscular process of the same side,
3. **Cricothyroid** muscle (*tensor*): from external aspect of cricoid to inferior border and lamina of thyroid cartilage,
4. **Thyroarytenoid** muscle (*relaxor*): from posterior surface of the thyroid cartilage to the muscular process of the arytenoid.

Blood Supply and Venous Drainage of the Larynx:

- superior and inferior thyroid arteries.
- venous drainage by superior and middle thyroid veins to internal jugular v, and inferior thyroid vein to left brachiocephalic v.

Nerve Supply of the Larynx:

i) **Superior laryngeal N.** (br of CN X):

- external laryngeal n (motor) to supply cricothyroid and cricopharyngeus mm.
- internal laryngeal n (sensory) to mucous membrane above vocal folds, epiglottis, thyrohyoid membrane.

ii) **Recurrent laryngeal N** (br of CNX):

- motor- all intrinsic laryngeal mm. (except cricothyroid).
- sensory- to mucous membranes below vocal folds.

iii) **Autonomic**:

- parasympathetic- CNX, sensory and motor.
- sympathetic- from superior and middle cervical ganglia, vasomotor.

Movements Of The Vocal Folds:

i) **Quiet respiration**:
- The anterior *intermembranous* part of the rima glottidis is triangular, the posterior *intercartilaginous* part is rectangular.

ii) **Forced inspiration**:
- The vocal folds are fully abducted,
- The arytenoid processes rotate laterally, their vocal processes moving apart.

iii) **Phonation** (studied with high-speed cinematography):
- In preparation to phonation the *intercartilaginous* and *intermembranous* parts of the glottis are reduced to a linear chink by adduction of the vocal folds and adduction and medial rotation of the vocal processes.
- The folds then tense, the degree of tension determining the pitch of the voice. More tension means higher frequency. Folds may lengthen by 50% in highest tones.

iv) **Whispering**:
- The *intermembranous* part of the glottis is closed.
- The *intercartilaginous* part of the glottis remains widely open, so that air can escape freely.

Process of Phonation/Speech:

Phonation or speech requires three things:
- A source of energy (expired air)
- Structures capable of periodic and aperiodic oscillation (vocal folds)
- A resonator (the column of air extending from the vocal folds to the lips and nostrils).
- The available increase in length alone of the vocal folds (50%) **cannot** account for all the available range of human speech frequencies (60 to 500 Hz), let alone singing. Variations in mass and tension of the vocal folds are also believed to play important parts.
- As stated above, in phonation the vocal folds are initially in contact. As air pressure increases below the vocal folds they are suddenly forced apart, recoiling elastically because pressure momentarily drops. This cycle is repeated at a fundamental frequency (and its harmonics).
- Some harmonics are damped by the 'column' of air above the folds and some are enhanced to produce the required tone. Resonators are located in the laryngopharynx, oropharynx, soft palate and tongue.
- The tone (essentially vowels) so produced must be modified by articulation (introduction of consonants).
- Consonants are named after the anatomical sites where they are produced:
  - Labials (*p* and *b*)
  - Dentals (*t* and *d*)
  - Nasals (*m* and *n*)
  - Back of tongue and soft palate (*k*)
- All these sites have two things in common:
  - A partial obstruction of the vocal tract,
  - Production of aperiodic vibration (noise), superimposed on the laryngeal tones.

3. The Thyroid Gland:

Gross anatomy, blood and nerve supply:
- Lies level with the 5th cervical to 1st thoracic vertebrae.
- Is ensheathed by the pretracheal layer of deep cervical fascia.
- Has **right and left lobes** connected by a narrow, median **isthmus**.
- Weighs about 25 g.

- Lobes extend as far superiorly as the oblique lines on the laminae of the thyroid cartilages. Bases of the cone-shaped lobes lie at the level of the 4th or 5th tracheal cartilages.
- Lateral aspect is covered by the sternothyroid muscle.
- Medial surface is related to the larynx, trachea and external and recurrent laryngeal nerves and the esophagus are important medial relations.
- Posterior border is related to the **parathyroid glands** (2 each side).
- A conical **pyramidal lobe** often ascends from the isthmus towards the hyoid bone, and accessory thyroid glands may occur above the lobes or isthmus.

Relations of the thyroid:

I) anterior: sternothyroid and sternohyoid mm.

II) lateral: carotid sheath and its contents (internal jugular vein and vagus nerve; superior root of the ansa cervicalis is embedded in its anterior wall).

III) posterior: larynx, pharynx, and esophagus.

Blood supply of the thyroid gland:

I) superior thyroid a. From external carotid a.

II) inferior thyroid a. From thyrocervical trunk, a br of the subclavian a.

III) venous drainage: superior and middle thyroid vv drain into internal jugular. Inferior thyroid v. Drains into the left brachiocephalic v.

Nerve supply of the thyroid gland:

- Autonomic fibres from the vagus and superior, middle and inferior cervical sympathetic ganglia.

4. The Vagus nerve CNX:

- Mixed nerve with sensory, motor and parasympathetic preganglionic.
- Leaves the cranium via the jugular foramen, sharing an arachnoid and dural sheath with the accessory nerve.
- Possesses two ganglia, superior (jugular) and inferior (nodose), above and below the jugular foramen respectively. Both are exclusively sensory ganglia, containing somatic, special visceral and general visceral afferent neurons. Efferent fibres pass unsynapsed through the ganglia.
- The vagus descends vertically in the neck in the carotid sheath, between the internal jugular vein and the internal carotid artery to the thyroid cartilages upper border, and then passes between the vein and the common carotid artery to the root of the neck.
- Once in the thorax the courses differ according to side.

Right vagus nerve:

Descends posterior to the internal jugular v., passes through the superior mediastinum behind the Rt brachiocephalic v.

It then passes behind the Rt principal bronchus to posterior aspect of Rt hilum to divide into posterior pulmonary plexuses, which unite with rami from the 2nd to 6th (7th) thoracic sympathetic ganglia to form the pulmonary plexuses.

Fibres descend from there to form (with Lt vagal ramus) the posterior esophageal plexus, which traverse the diaphragmatic esophageal opening.

In the abdomen it gives small gastric brr (to posterior-inferior stomach surface, except pylorus) and large coeliac brr (to form coeliac plexus).

Left vagus nerve:

Enters the thorax between the Lt common carotid and subclavian arteries.

Divides into **posterior pulmonary** brr, which unite with rami of 2nd to 4th thoracic sympathetic trunk to form the posterior pulmonary plexus, two brr of which descend anterior to the esophagus as the anterior esophageal plexus.

The **esophageal plexus** on the anterior and posterior aspect of the esophagus just proximal to its entrance through the esophageal hiatus form the anterior and posterior vagal trunks.

The **anterior** and **posterior vagal trunks** in front and behind the abdominal part of the esophagus via their contribution to coeliac plexus and individual branches supply the cardiac portion of stomach, anterosuperior gastric surface, liver, pancreas, pylorus, superior and descending duodenum ("coeliac trunk territory"); as well as rest of duodenum and small and large intestines up to the left colic flexure ("superior mesenteric territory"). One can generalize by saying that the vagus is distributed to the abdominal viscera/ structures that are supplied by coeliac trunk and superior mesenteric arteries).

Branches

In the neck:

i) Pharyngeal - to pharyngeal and palatal mm.

ii) Brr to carotid body

iii) **Superior laryngeal** - internal, external laryngeal n. branches

internal laryngeal nerve- sensory to the laryngeal mucosa down to vocal folds.

external laryngeal nerve- supplies inferior constrictor and cricothyroid.

iv) **Recurrent laryngeal** - laryngeal mm, except cricothyroid, sensory to larynx below vocal folds, laryngeal stretch receptors.

v) **cardiac brr**

vi) anterior and posterior pulmonary brr

vii) esophageal, gastric, coeliac, hepatic and renal brr- to be dealt with individual sections.

Materials: **Bones:** articulated skeleton, skulls, loose ethmoid, sphenoid and maxilla bones; **Prosected specimens**: superficial head & neck; deep head & neck; pharynx head; coronal face; superficial thorax superficial; deep thorax deep; Plastinated head and neck specimen; Loose/isolated larynx specimens **Models**: nose; Models small and large larynx; Torso model; ***X-ray:*** box HNF, visceral.

TUTORIAL/LABORATORY CLASS 3

THE THORAX, MEDIASTINUM AND PLEURA

Aims: To understand the gross anatomy of the thoracic wall, mechanism of respiration and the boundaries and contents of the mediastinum. This will form the basis for the gross anatomy of thoracic viscera and related structures.

Specific objectives

1. To revise the bones and the muscles of the thoracic cage and relate these to the movements of respiration.
2. To identify the main features of the bones of the thoracic cage.
3. To identify and name the intercostal muscles and the diaphragm and associated neurovascular structures: the phrenic nerves, the intercostal nerves, arteries and veins.
4. To identify the attachments and nerve supply of the diaphragm.
5. To identify the positions, vertebral levels and boundaries of the three main openings in the diaphragm.
6. To state the actions of the intercostal muscles and diaphragm and describe their function in movements of respiration. To give a short description of the neural control of breathing.
7. To understand the structure, connections and clinical significance of the vertebral venous plexus.
8. To define the mediastinum, its divisions and contents.
9. To understand the pleura and the relationship of visceral and parietal pleura to lung.

Learning activities

1. Examine the boundaries of **superior and inferior thoracic aperture**.
2. Examine specific features of the skeleton of thorax: **sternum, ribs, and thoracic vertebrae**.

3. Identify the **intercostal space**, its boundaries, the intercostal muscles and contents.
4. Identify the **azygos venous system**: the azygos, hemiazygos and accessory hemiazygos veins. Make a diagram of the **azygos system of veins**.
5. Discuss with colleagues the structure and significance of the vertebral venous plexus.
6. Identify the parts of **diaphragm**. Identify the important apertures in the diaphragm, their location, vertebral levels and structures passing through these apertures.
7. Identify the **phrenic nerve**.
8. Identify the divisions, boundaries and contents of mediastinum.
9. Identify the **pleura**, the fibrous membrane that covers the lungs and lines the thoracic cavity. The part of the pleura adherent to the surface of the lung (except at the hilum) and the fissures is called the **pulmonary** or **visceral pleura**, while the pleura which lines the thoracic cavity, diaphragm and mediastinal contents is called the **parietal pleura**. The parietal and visceral pleura are separated by a potential space (**pleural sac or cavity**). Note the existence of the **costomediastinal** and **costodiaphragmatic recesses**. These lie at the reflections of parietal pleura from costal surface to mediastinal and to diaphragmatic surfaces respectively. During quiet respiration, these recesses are filled only by thin film of fluid. During deep inspiration the lung will expand into these recesses.
10. Discuss the movements of thorax and mechanism of ventilation. Discuss the articulation of the ribs and their movements:
11. Vertebrosternal (true ribs) "pump handle"
12. Vertebrochondral (false ribs) "bucket handle"
13. Vertebral (floating ribs)
14. With colleagues recall the means by which thoracic diameters are altered during respiration. Define "bucket handle" and "pump handle" movement of the ribs and their respective roles in the mechanism of respiration.
15. With colleagues, observe the movements of thorax and abdomen during respiration. Discuss the function of the respiratory muscles paying particular attention to the effect their contractions will have on the volume of the thoracic and abdominal cavities. Deduce the effect of contractions of the diaphragm.
16. Study radiographs of chest and identify bony landmarks and soft tissue shadows.
17. *Discuss clinical relevance of vertebral venous plexus and carcinoma of the breast and prostate gland.*
18. **Discuss the clinical problems 11, 12, and 13**.

Lecture Notes:

1. **Thorax**: the skeleton of thorax is made of:
    a. The **sternum**: The sternum consists of **manubrium**, **body** and **xiphoid process**. The **manubrium sterni** has a **jugular notch**, **clavicular notches** for articulation with the clavicle, **facets for the 1st ribs and 2nd ribs**. The latter articulate at the **manubriosternal joint** (a symphysis). The **body of the sternum** is formed from fusion of 4 sternebrae and may possess three variable transverse ridges representing the lines of fusion. The **sternal angle** (at the manubriosternal joint) lies at the level of the disc between T4 and T5 posteriorly and the 2nd costal cartilage anteriorly
    b. The **ribs**: Note a **typical rib** has: **head**, **neck**, **shaft**, **articular surfaces**, **tubercle**, **angle** and **costal groove** of a typical rib. Ribs 1 to 7 articulate with the sternum by **costal cartilages** and are called **true ribs**. Ribs 8, 9, 10 are connected to the suprajacent costal cartilages as they approach the sternum forming the costal margin and are called **false ribs**. Ribs 11 and 12 are not connected to the sternum at all and are called **floating ribs**. The features of a typical rib include: a **shaft** with anterior and posterior ends. The anterior or costal end has a depression for its costal cartilage's lateral end. The shaft has an external convexity and is grooved internally near its lower border (the **costal groove**). The costal groove of most ribs, protects the **posterior intercostal vein, posterior**

intercostal artery and intercostal nerve; in that order from deep to superficial (VAN). The posterior or vertebral end has a **head**, with two **articular facets** for the vertebral bodies, separated by an **interarticular crest** (which will lie adjacent to the intervertebral disc). The **neck** is the flattened part behind the head, which lies anterior to the corresponding number transverse process. The **tubercle** is posterior and external to the junction of the neck and shaft. It is divided into medial **articular** and lateral **non-articular areas**. The articular area bears a small oval facet for the corresponding facet on the transverse process of the same number rib. The shaft is bent at a **posterior angle**, 6 cm from the tubercle.

c. **Thoracic vertebrae**: Note that a **typical thoracic vertebra** has a **vertebral body** with two **costal demi/hemi facets** (superior and inferior). The superior pair of **demi/hemi** facets is usually larger and lies anterior to the **pedicles**. The inferior pair is smaller and lies anterior to the **vertebral notches**. **Laminae** are short, thick and broad and tend to overlap from above downwards. The **vertebral foramen** is bound superiorly by the superior and inferiorly by the inferior vertebral notches, **spinous processes** that slant downwards, and **superior and inferior articular processes**. **Transverse processes** bear oval **facets** for articulation with the **tubercles** of the correspondingly numbered rib.

2. **Movements of thorax**: Study the articulation of the ribs and their movements: note that the Vertebrosternal (true ribs) are responsible for “pump handle"; the Vertebrochondral (false ribs) are responsible for “bucket handle" movements of the thoracic wall. The Vertebral (floating ribs) are embedded in the musculature of the anterior abdominal wall.

3. **Mechanism of Ventilation**: With colleagues discuss the mechanism of ventilation and the means by which thoracic diameters are altered during respiration. Define "bucket handle" and "pump handle" movement of the ribs and their respective roles in the mechanism of respiration. The Movements of Ventilation:

   I) Pump handle movement: is produced by the elevation of distal (anterior) ends of ribs. It particularly involves the so-called *vertebrosternal* ribs (2 to 6). It increases the AP diameter of the thorax.

   II) Bucket handle movement: is produced by elevation of the shafts of ribs outward and backward. It particularly involves the *vertebrochondral* ribs (7 to 10). It increases the transverse diameter of the thorax.

4. **Intercostal space**: the intercostal space is the potential space between two adjacent ribs. It is bound from external to internal by the intercostal muscles: i) **external intercostals** extend forward and downwards from one rib to its inferior neighbor; ii) **internal intercostals** pass superiorly and anteriorly from each rib to its suprajacent neighbor; iii) **innermost intercostals** lie in the middle 2/4 of the thoracic wall, have fibres running in the same direction as the internal intercostals and note that the intercostal vessels and nerve in the costal groove disappear deep to the innermost intercostals muscles. The contents of the intercostal space include: **intercostal vessels** and **nerves**. Each space contains a posterior intercostal artery, intercostal vein, intercostal nerve and a pair of anterior intercostal arteries.

5. **Intercostal muscles**:

   i) **External intercostals**: 11 pairs. They extend forward and downwards from one rib to its inferior neighbor. They are not present anterior to the costal cartilages where they are replaced by the external intercostal membrane. *They are active during inspiration and the early part of expiration*.

   ii) **Internal intercostals**: also 11 pairs. They pass superiorly and anteriorly from each rib to its suprajacent neighbor. They are not present posterior to the costal angles where they are replaced by an internal intercostal membrane. *Interosseus parts of internal intercostal muscles are believed to be expiratory, while intercartilaginous parts of the muscle are believed to be inspiratory*.

   iii) **Innermost intercostals**: often absent, they lie deep to the intercostal vessels and nerve. *May be expiratory, but no firm information is available*.

iv) Subcostal mm: really just musculo-aponeurotic fasciculi, which lie deep to the innermost intercostals. They probably cause costal depression.

6. **Accessory muscles of ventilation**.
   Accessory muscles of ventilation are of use in forced inspiration/expiration. Following are some of these muscles:

   a) anterolateral abdominal wall muscles: external oblique, internal oblique, transversus abdominis and rectus abdominis. These are all expiratory muscles by raising intra-abdominal pressure, in turn elevating the diaphragm and reducing the thoracic cavity volume.
   b) scalenus anterior, scalenus medius, scalenus posterior (inspiratory).
   c) sternomastoid (inspiratory).
   d) extensors of the spine (inspiratory).
   e) pectoralis major, serratus anterior (inspiratory). These muscles require that the upper limb girdle be fixed by holding onto chairs etc. before they can act as inspiratory mm.

7. The **azygos venous system**: The venous drainage of the Thorax and some parts of the abdomen are done by a complex system of venous channels and these collectively contribute to the **azygos venous system**. It comprises *three* major channels:

   The **azygos** vein is formed in the abdomen by the union of right subcostal vein and right ascending lumbar vein. The azygos vein enters the thoracic cavity accompanied by the thoracic aorta and the thoracic duct, by passing through the aortic hiatus in the diaphragm. Tributaries of azygos vein include 11 – 5 right posterior intercostal veins, right superior intercostal vein, hemiazygos and accessory hemiazygos veins.

   The **hemiazygos** vein is similarly formed by the union of ascending lumbar and subcostal vein on the left side and enters the thoracic cavity by passing deep to the left dome of diaphragm. It receives 11 – 8 left posterior intercostal veins, crosses the vertebral column at the level of T8 vertebra to enter the azygos vein.

   The **accessory hemiazygos vein** is formed by the union of 5^{th}, 6^{th} and 7^{th} left posterior intercostal veins, crosses the vertebral column at the level of T7 to enter the azygos vein. The azygos vein drains into the superior vena cava at the level of TV4.

8. **Diaphragm**: The **diaphragm** is the fibromuscular partition between the thorax and abdomen. It has **muscular** fibres with **sternal**, **costal**, and **vertebral** attachments; and tendinous attachments with the median, medial and lateral arcuate ligaments and the **central tendon**.

   The **sternal part** is attached to the posterior surface of the xiphoid process. The **costal part** attaches to the internal surfaces of the lower 6 costal cartilages and the adjoining ribs. The **vertebral** or **lumbar part** attaches to the vertebrae by crura (right and left) and to the medial and lateral arcuate ligg.

   The **right crus** is attached to the bodies of upper 3 lumbar vertebrae, the **left crus** is attached to the bodies of upper two lumbar vertebrae. Their medial tendinous margins converge in a median arch across the aorta at the level of the TV12/LV1 intervertebral disc (**median arcuate ligament**). The **lateral arcuate ligament** is a thickened band of fascia on the quadratus lumborum, which arches across this muscle and attaches to the front of the 1st lumbar transverse process. The **medial arcuate ligament** is a tendinous arch in the fascia covering psoas major.

   The **central tendon** is a thin aponeurosis, which lies beneath the pericardium and is partly blended with it. It receives the attachment of all the muscular fibres of the diaphragm. It consists of **central area** and **right and left leaves**.

   Opening/hiatuses of the diaphragm: Note that several structures are related to or pass deep to or pierce the diaphragm to exit or enter the thoracic cavity for e.g.: the sympathetic trunks, greater, lesser and least splanchnic nerves, subcostal vessels and nerves, hemiazygos vein, superior epigastric vessels, musculophrenic vessels. Identify the following important apertures in the diaphragm:

   a. **Aortic hiatus/aperture**: at the level of the caudal border of the TV12, lying behind the median arcuate ligament. It transmits the aorta, thoracic duct and azygos vein.

b. **Esophageal hiatus/aperture**: lies opposite the TV10. It lies between the fibres derived from the right crus of the diaphragm, which have now crossed the midline. It transmits the esophagus, anterior and posterior vagal trunks, and esophageal branches of left gastric artery.

c. **Vena caval hiatus/aperture**: lies at the level of TV8/9 intervertebral disc within the central tendon, at the junction of the right leaf and the central area. It transmits the inferior vena cava and the right phrenic nerve.

d. In addition there are openings or passages in or under various attachments of diaphragm for splanchnic nerves, sympathetic trunks, subcostal nerves and vessels.

Nerve supply of the diaphragm: phrenic nerve is the sole motor supply of diaphragm. Phrenic nerve also supplies sensations to the central part of diaphragm. The peripheral parts of diaphragm are supplied by the intercostal nerves.

Clinical: The **diaphragmatic hernia**: *A diaphragmatic hernia is a displacement or protrusion of an organ or structure through a weak area or a defect in the diaphragm*. Such a hernia may be present by birth or may be caused by trauma and almost every organ has a chance to be herniated into the thoracic cavity from the abdominal cavity. Occasionally the diaphragm may present with congenital diaphragmatic hernia through gaps in costal part, through esophageal opening, or through sternocostal triangle.

9. **Phrenic nerve**: Study the course of the **phrenic nerve (C3, C4, C5)** in the neck and thorax. Discuss the motor and sensory distribution of the phrenic nerve. Note that the right phrenic nerve passes through the inferior vena caval hiatus accompanied by the IVC and the left phrenic nerve pierces the left dome of the diaphragm. Remember the mnemonic in relation to its most important function, *"C3, 4, 5, keeps the diaphragm alive"*.
10. **Process of respiration**: With colleagues, observe the movements of thorax and abdomen during respiration. Discuss the function of the respiratory muscles paying particular attention to the effect their contractions will have on the volume of the thoracic and abdominal cavities. Deduce the effect of contractions of the diaphragm. Discuss the role of the accessory respiratory muscles during inspiration and expiration.
11. The **vertebral venous plexus**. Note that the veins that drain the region of the back form plexuses around the vertebral column, extending from the base of skull to the coccyx.

    These venous plexuses are divisible into *external vertebral venous plexus* (lying outside the vertebral column and surrounding it) and the *internal vertebral venous plexus* (lying within the vertebral canal but outside the duramater).

    The internal vertebral venous plexus receives tributaries from the vertebrae (*basivertebral veins*), and drain into the intervertebral venous plexus (accompanies the spinal nerve in the intervertebral foramen).

    The external vertebral venous plexus drains into the intervertebral venous plexus and this in turn finally drains into vertebral, intercostal, lumbar and lateral sacral veins.

    These venous plexuses freely communicate with the veins in the neck, thorax, abdomen and pelvis. Proximally they communicate with the venous sinuses in the cranial cavity. It is of considerable clinical importance that these venous plexuses and related veins either have no valves or very poorly developed valves and thus can allow for free venous blood flow between the skull, neck, thorax, abdomen, pelvis and vertebral column.
12. **Mediastinum**: Examine the thorax specimens and models and define the boundaries of the **mediastinum**. Note that the middle region of thoracic cavity, called the mediastinum is divisible into a **superior mediastinum** and an **inferior mediastinum** by an imaginary line that passes from the sternal angle anteriorly and the disc between the T4 and T5 vertebra posteriorly. The inferior mediastinum is further divided into an **anterior mediastinum** anterior to the heart, the **middle mediastinum** with the heart within pericardium, and the **posterior mediastinum** posterior to the heart. Identify the structures located in each of these compartments.

a. **Superior mediastinum**: trachea, esophagus, thymus, aortic arch, brachiocephalic trunk, left common carotid a., subclavian aa., superior vena cava, brachiocephalic vv., vagus n., recurrent laryngeal nn, phrenic nn, and cardiac sympathetic nn.
b. **Middle mediastinum**: heart and pericardium, roots of great vessels, proximal end of azygos v., and phrenic n.
c. **Anterior mediastinum**: superior and inferior sternopericardial ligg., internal thoracic vessels, lymph nodes, and thymus.
d. **Posterior mediastinum**: esophagus, trachea, bronchi, thoracic aorta, thoracic duct, azygos and hemiazygos vv, vagus n., splanchnic nn, and lymph nodes.

13. **Pleura**: Each lung is covered by **pleura**, a serous membrane arranged as a closed invaginated sac.

That part of the pleura adherent to the surface of the lung (except at the hilum) and the fissures is called the **pulmonary** or **visceral pleura**, while the pleura which lines the thoracic cavity, diaphragm and mediastinal contents (actually a continuation of the visceral pleura) is called the **parietal pleura**.

The parietal pleura is divided into several regions according to the structures adjacent to it:

i) **costovertebral (costal) pleura**: adjacent to the ribs and vertebrae.
ii) **diaphragmatic** " " " " diaphragm.
iii) **mediastinal** " " " " " mediastinum.
iv) **cervical pleura (domes of the pleura)**: over the apices of the lungs and adjacent to cervical structures.

The costovertebral pleura is separated from the sternum, ribs, transversus thoracis and intercostal mm and sides of vertebral bodies by endothoracic fascia, a thin areolar layer.

The cervical pleura is strengthened by a fascial suprapleural membrane, which is attached in front to the 1st rib's internal border and behind to the anterior border of the 7th cervical vertebra transverse process.

The parietal and visceral pleura are separated by a potential space (**pleural sac or cavity**), which is filled in life by only a thin film of fluid. The right and left pleural sacs touch only behind the upper half of the sternal body, although they come close to each other behind the esophagus at the mid-thoracic level.

Note the existence of the **costomediastinal** and **costodiaphragmatic recesses**. These lie at the reflections of parietal pleura from costal surface to mediastinal and to diaphragmatic surfaces respectively. During quiet ventilation these recesses are filled only by thin film of fluid. During deep inspiration the lung will expand into these recesses.

The surface features, which mark the boundaries of the parietal pleura are as follows:

a) Rt pleural sac: (Rt sternoclavicular joint) to (sternal angle in the midline) to (4th costal cartilage level in the midline) to (Rt back of the xiphisternal joint) to (Rt 8th rib in the midclavicular line) to (Rt 10th rib in the midaxillary line) to (Rt 12th thoracic spine).

b) Lt pleural sac: (Lt sternoclavicular joint) to (sternal angle in the midline) to (4th costal cartilage level in the midline) to (Lt 6th costal cartilage 2 to 25 mm from the sternal edge) to (Lt 8th rib in the midclavicular line) to (Lt 10th rib in the midaxillary line) to (Lt 12th thoracic spine).

Blood supply of the pleura

The parietal pleura:

From the arteries supplying the thoracic body wall and mediastinum. eg: internal thoracic a. and its anterior intercostal, musculophrenic artery, posterior intercostal arteries from the aorta and highest intercostal arteries from the subclavian a.

The Visceral pleura:

Blood supply is received from the bronchial arteries (brr of aorta) see below.

Nerve supply to the parietal pleura:

i) to costal pleura from the intercostal nerves.

ii) to mediastinal and diaphragmatic pleura from the phrenic n.

The Visceral pleura:

Nerve supply is derived from autonomic nerves from pulmonary plexuses (see below).

Materials: ***Bones:*** Articulated skeleton; Vertebral column on a rod or string, Isolated Ribs, thoracic vertebrae and sternum; ***Prosected specimens*****:** Deep and superficial prosections of the thorax; right and left lungs; ***Radiographs*** of the chest; ***Models:*** torso models

TUTORIAL/LABORATORY CLASS 4
LOWER RESPIRATORY TRACT: TRACHEA, BRONCHII AND LUNGS

Aims: To know the major structural features of the respiratory passages and the lungs.

Specific Objectives

1. To describe the structure and position of the trachea, bronchi and lungs, including the concept and significance of broncho-pulmonary segments.
2. To describe and identify the major relations of the trachea and bronchi and the medial relations of each lung.
3. To demonstrate the relationship of visceral and parietal pleura to lung.
4. To identify right and left lungs and structures at their hila.
5. To state the blood supply, lymphatic drainage and basic pattern of innervation of the lungs, trachea and bronchi and pleura.
6. To interpret P-A radiographs of normal thorax and bronchograms.

Learning Activities

1. Identify the **trachea** and its division into main **principal** or **pulmonary bronchi** at the level of upper border of TV5. Identify at the bifurcation of the trachea an internal ridge known as the **carina**. Refer to your lecture notes, identifying as many relations of the trachea as possible. *If you had to perform an emergency **tracheotomy** where would be the safest site(s) to make the tracheal incision and why?*
2. The **principal bronchi** extend from the tracheal bifurcation to the further division of the airways to form **lobar bronchi**. The Rt principal (or main) bronchus is wider, shorter and more vertical than the left. The **Rt main bronchus** gives off the **Rt superior lobe bronchus** before it enters the substance of the lung. Once it enters the hilum it divides into **Rt middle** and **inferior lobe bronchi**. Thus the Rt main bronchus has an extra-pulmonary portion. The **Lt main bronchus** is much longer than the Rt and divides after entering the hilum into **Lt superior lobar bronchus** and **Lt inferior lobar bronchus**.
3. With colleagues examine the **right** and **left lungs**. Note each lung has an **apex**, a **base**, three **borders**, and two **surfaces**. Examine the **fissures** and the **lobes** of the lungs. Identify the **impressions** on the **mediastinal surfaces** of the **right** and **left lung.** Identify the **pulmonary ligament**.
4. Identify the comma shaped structure called the **hilum** on the mediastinal surface of the lungs. With colleagues list the structures entering or leaving the lung at the hilum.
5. Discuss the blood supply and lymphatic drainage of the lungs and the basic pattern of innervation. Identify the **anterior and posterior pulmonary plexuses**.
6. There are **anterior and posterior pulmonary plexuses** located in front and behind the roots of the lung. These plexuses receive fibres from the vagus and sympathetic nerves.
7. **Radiographs**: Identify and count the **ribs**, identify the **trachea** and **hilar shadows** on PA and lateral radiographs of the chest. Identify **main**, **lobar** and **segmental bronchi** on the

bronchograms. To identify the trachea, bronchi and lungs and the features of pulmonary structure including the lobes, fissures and the visceral and parietal pleura. Identify immediate relations of the trachea in the neck and thorax.

8. Discuss the role of the accessory respiratory muscles during inspiration and expiration.
9. **Discuss the clinical problems 14, 15 and 16.**

Lecture Notes

1. **Trachea**: Identify the **trachea** extending from the larynx (CV6) to its division into main (principal or pulmonary) bronchi (upper border of TV5). At the bifurcation of the trachea there is an internal ridge known as the **carina**. The **trachea** is about 10 to 11 cm long and extends from the larynx (CV6) to its division into main (principal or pulmonary) bronchi (upper border of the 5th thoracic vertebra). During deep inspiration the tracheal bifurcation may descend to the level of TV6.

   The trachea consists of 16 to 20 hyaline cartilaginous horseshoe shaped rings, discontinuous posteriorly where the defect is filled by the trachealis muscle (smooth muscle), which extends between the ends of the tracheal cartilaginous rings. At the bifurcation of the trachea there is an internal ridge known as the **carina** (Latin: keel of ship)

   Blood supply of the trachea is by the superior and inferior thyroid aa, and bronchial aa.

   Venous drainage is into the inferior thyroid vv.

   Lymphatic drainage is to cervical, tracheal and tracheobronchial lymph nodes.

   Nerve supply is by the vagus, recurrent laryngeal nerves and fibres from the cervical sympathetic chain.

   Relationships: The trachea passes through the neck, superior and inferior mediastinum and has important relations in each of these regions:

Region	Anterior	Posterior	Lateral
Cervical	Sternohyoid m. Sternothyroid m. Thyroid isthmus Thymus remnant Inferior thyroid vv.	Esophagus Recurrent laryngeal nn.	Thyroid lobes Common carotid a. Inferior thyroid a.
Thoracic	Manubrium sterni Thymus Inferior thyroid v. Left brachiocephalic v. Arch of aorta Brachiocephalic trunk Left common carotid a. Deep cardiac plexus Lymph nodes Sternothyroid m. Sternohyoid m.	Esophagus Vertebral column	Lungs and pleura Right brachiocephalic v. SVC (on the right) Right vagus n. Azygos v. (on right side) Arch of aorta Left CCA Lt. subclavian a. Lt recurrent laryngeal n.

2. **Bronchi**: The **principal bronchi** extend from the tracheal bifurcation to the further division of the airways to form **lobar bronchi**. The right principal (or main) bronchus is wider, shorter and more vertical than the left. The **right main bronchus** gives off the **right superior lobe bronchus** before it enters the substance of the lung. Once it enters the hilum it divides into **right middle** and **inferior lobe bronchi**. Thus the right main bronchus has an extra-pulmonary portion. The **left main bronchus** is much longer than the right and divides after entering the hilum into a **left superior lobar bronchus** and a **left inferior lobar bronchus**.

3. **Lungs**: The lungs are spongy and float on water, due to air remaining in the alveoli. At birth the lungs are pink, while in adults the lungs become increasingly discolored by a dark mottling. This is the accumulation of dark carbonaceous material deposited in loose connective tissue near the surface (beneath the visceral pleura). Lungs from smokers and those living in industrialised areas are particularly affected.

   Lungs from stillborn infants who have not expanded their lungs in air differ from those infants who have, in that the former lungs are firm, non-crepitant and sink in water.

   Each lung has an **apex**, a **base**, **three borders** and **two surfaces**.

   The **apex**: protrudes above the thoracic inlet.

   The **base** rests on the diaphragmatic superior surface. Since the diaphragm extends higher on the right than the left (due to the liver), the concavity is deeper on the right. The **costal surface** is adapted to the thoracic wall and bears the impressions of the ribs. The **medial surface** consists of: anterior, **mediastinal** and posterior, **vertebral** parts. The mediastinal part is adapted to the heart as the cardiac impression, which is particularly impressive on the left lung.

   The comma-shaped **hilum** is on the medial surface, with several important structures within it: **pulmonary artery and veins**, **bronchi**, **bronchopulmonary lymph nodes**.

   The **inferior border** separates the base from the costal and mediastinal surfaces and extends into the costodiaphragmatic recess. The **anterior border** shows a variable **cardiac notch** on the left. The **posterior border** separates the costal surface from the vertebral part of the medial surface, along a line corresponding to the heads of the ribs.

   The lungs are divided into lobes: two on the left: **upper** and **lower** and three on the right: **upper**, **middle** and **lower**.

   These lobes are separated by gaps called the **fissures**: identify **oblique** fissure on the left, and **oblique** and **horizontal** fissures on the right.

   Impressions and relations of the lungs: The lungs of the living are sponge like structures and bear no impressions but after death the lungs harden and the surrounding structures as they lie close to the various surfaces of the lungs will leave an impression. Thus the costal surface bears the impressions of the ribs, the diaphragmatic surface bears the impression of the domes of the diaphragm. Several important visceral relations give rise to impressions on the medial/ mediastinal surface of the fixed lung.

   On the mediastinal surface of left lung: **pericardial sac**, **aortic arch**, **left subclavian a.**, **esophagus**, trachea, and **left brachiocephalic v**.

   On the mediastinal surface of right lung: pericardial sac, **SVC**, **right brachiocephalic v.**, **azygos v.**, **esophagus**, and trachea.

   Note also the **pulmonary ligament** extending inferiorly from the hilum as a reflection of visceral pleura.

   Each segmental bronchus supplies a structurally separate, functionally independent unit of lung tissue known as a **bronchopulmonary (BP) segment**. There are of course 10 BP segments in each lung and they are separated by fibrous tissue septa, which are continuous with the visceral pleura. Branches of the pulmonary arteries tend to follow the bronchi so they also tend to supply BP segments. Pulmonary veins are intersegmental in drainage and do not accompany the bronchi.

   Nerve supply: The nerve supply of the lungs is by the autonomic plexuses and their composition as they travel related with pulmonary vessels. There are **anterior and posterior pulmonary plexuses** located in front and behind the roots of the right and left lung. These plexuses receive parasympathetic fibres from the recurrent laryngeal nerve and the vagus nerve of the respective side; and the sympathetic fibres reach the plexus from the segments T1-T4 of the spinal cord.

Materials: **Bones:** Articulated skeleton; **Prosected specimens:** Thorax, superficial and deep; dissected, isolated lungs both right and left, dissected lungs with bronchial tree; **Models:** torso, larynx; **Radiographs** of chest and bronchograms.

TUTORIAL/LABORATORY CLASS 5
THE PERICARDIUM AND HEART

Aims: To know the major structural features of the pericardium. To know: location, external features, and internal features of the heart and its chambers.

Specific Objectives

1. To state the extent and attachment of the fibrous pericardium. To define visceral and parietal layers of pericardium. To describe the transverse and oblique sinuses of the pericardium, and to understand the innervation of various layers of the pericardium.
2. To know the external features of the heart and the cardiac apex.
3. To identify the venae cavae, pulmonary vessels, atrioventricular and interventricular grooves and the sulcus terminalis.
4. To know the openings of the right atrium, the crista terminalis, musculi pectinati, interatrial septum, fossa ovalis, auricle and opening of the coronary sinus.
5. To know the openings of the right ventricle including features of the atrioventricular valve and its opening and the pulmonary valve and its opening. To identify trabeculae carneae, chordae tendineae, papillary muscles and the infundibulum.
6. To know the openings of the left ventricle and the features of the valves guarding the opening, the papillary muscles and the muscular part of the interventricular septum. To identify the internal features of the left atrium and its openings.
7. To compare the functional anatomy of right and left ventricles.
8. To consider the importance of the cardiac fibrous skeleton.
9. To identify the ascending aorta, arch and descending aorta; the brachiocephalic trunk, right and left common carotid, subclavian and internal thoracic arteries; superior and inferior venae cavae, brachiocephalic, subclavian, azygos and jugular veins.

Learning activities

1. Identify the **parietal** and **visceral** layers of the **serous pericardium** and attachment of the **fibrous** and parietal pericardium to the roots of great vessels and to the diaphragm.
2. Identify the extent of the pericardial cavity and identify **transverse** and **oblique pericardial sinuses**.
3. Identify the **borders, surfaces, base and apex of the heart**.
4. Identify the **superior** and **inferior vena cavae** and the **sulcus terminalis**. Identify the tributaries of the superior vena cava.
5. Identify the internal structure of the **right atrium**: **sinus venarum**, **musculi pectinati, crista terminalis, interatrial septum, fossa ovalis, valve of inferior vena cava, and the valve and opening of the coronary sinus**. Identify the **right atrioventricular orifice**.
6. In the **left atrium**: identify the openings of the **right and left pulmonary veins**, the **interatrial septum**, and the **left atrioventricular orifice**.
7. In the **right** and **left ventricles** identify the **papillary muscles, trabeculae carnae, septomarginal trabecula (right ventricle), tricuspid and mitral valves**, and the **pulmonary and aortic semilunar valves**.
8. Identify the thick **interventricular septum** separating the right and left ventricles.
9. Identify the branches of **ascending and arch of aorta**.
10. Discuss with your tutor the significance of cardiac fibrous skeleton.

11. Discuss the consequences of the valvular stenosis and incompetence.
12. Examine the radiographs of the chest: PA and lateral and identify the cardiac silohouette. Discuss the structures forming the right and left borders of the heart.
13. Examine the angiograms and radiographs of the cardiac catheterization and identify the major blood vessels entering and leaving the heart.
14. **Discuss clinical problems 17, 18 and 19.**

Lecture Notes

I The Heart

1. **External features** of the heart. The heart possesses an **apex**, which projects to the left and inferiorly, reaching the 5th left intercostal space in the midclavicular line; a **base**, where great vessels enter and leave the heart; three **surfaces**: **anterior or sternocostal, inferior or diaphragmatic, and left or pulmonary.** And finally identify four **borders**: **superior, inferior, left and right**. Identify the **interventricular groove (sulcus)** between the left and right ventricles, the **coronary groove (sulcus)** between the atria and ventricles, the **sulcus terminalis** a groove extending from the superior vena cava to the inferior vena cava down the anterolateral aspect of the right atrium.

2. **Internal features** of the cardiac chambers.

   The **right atrium** has a smooth walled **sinus venarum** posteriorly, where the **superior** and **inferior vena cavae** enter, which is separated from the atrium proper by the **crista terminalis**, a muscular ridge which runs between the two caval openings on the lateral wall of the atrium and is continuous with the **valve of the inferior vena cava**. Note the **musculi pectinati**, muscular ridges which line the atrium proper (i.e. that part anterior to the crista terminalis) and auricle. The **fossa ovalis** is a depression, which lies on the septal wall of the atrium. It has a prominent margin, known as the **limbus fossa ovalis**, which was originally the fetal septum secundum. The **opening of the coronary sinus** (which drains the venous blood from much of the heart) lies between the inferior vena caval and atrioventricular orifices. The opening of coronary sinus is protected by **valve of the coronary sinus,** which prevents regurgitation of blood into the coronary sinus during atrial contraction. Identify the **right atrioventricular orifice** with the tricuspid valve lying antero-inferiorly. The tricuspid valve has **three leaflets** (**anterior, posterior and septal**). Dorsal to the septal leaflet of the tricuspid valve is an extension of the **membranous part of the interventricular septum**, which here separates the right atrium from the left ventricle.

   The **right ventricle** has **trabeculae carneae**, which are ridges, bridges and papillary muscles, giving the internal surface a corrugated appearance. **Papillary muscles**, one for each of the tricuspid valve leaflets (**anterior, postal and septal**) have **chordae tendineae** (collagenous bands) attached to their apices, and which in turn attach to the margins of the atrioventricular valve leaflets. The **septomarginal trabecula** (**moderator band**), a trabecula carnea, joins the septal wall to the base of the anterior papillary muscle. The **supraventricular crest** separates the atrioventricular orifice from the outflow tract. The outflow tract of the right ventricle (**conus arteriosus** or **infundibulum**) extends towards the **semilunar pulmonary valve** which has three cusps attached at their bases to a fibrous annulus. Nomina anatomica terminology calls them left, right and anterior. Each valve cusp has a **lunule**, (thickened edge) and a **nodule** (at the apex of the cusp).

   The **left atrium** has a **left auricle** extending anteriorly left of the pulmonary trunk. Four **pulmonary veins** (two on each side) enter the left atrium. The **valvule of the foramen ovale** lies on the **interatrial septal wall** corresponding to the floor of the fossa ovalis on the other side. Note the **left atrioventricular valve orifice** with mitral valve leaflets.

   The **left ventricle** has a **left atrioventricular orifice** with **mitral** (**bicuspid**) **valve** leaflets (**anterior and posterior**). **Trabeculae carneae**, **chordae tendineae** and **papillary muscles** are found as for the right ventricle, except that the left has two papillary muscles only (**anterior and posterior**) for the corresponding mitral valve leaflets. An **aortic vestibule**

leads to the **semilunar aortic valve**, which has three cusps, each with lunules and nodules as for the pulmonary valve. Nomina anatomica names the cusps **left, right and posterior**. The **interventricular septum** has **muscular** (inferior) and **membranous** (superior) **parts**, the latter part lies towards the aortic valve and is partly confluent with fibrous supports of the right and posterior cusps (see right atrium).

3. **General Structure of the Cardiac Wall**

The cardiac wall consists of three layers:

- internal layer, the **endocardium**, continuous with the endothelium of the great vessels.
- muscular layer, the **myocardium**.
- subepicardial fat and connective tissue beneath the visceral layer of the serous pericardium also called the **epicardium**.

Cardiac fibrous skeleton: The intercellular spaces between the conducting and contractile elements of the heart are filled with connective tissue. Approximately along the plane of the coronary sinus, i.e. at the atrioventricular base, and intimately related to the valve orifices of the atrioventricular and semilunar valves, is a complex framework of dense collagen, with membranous, tendinous and fibro-areolar extensions. This is known as the *cardiac fibrous skeleton*.

The skeleton has several functions:

- to ensure electrophysiological discontinuity between the atria and ventricles (only connection is via the atrioventricular bundle; see next lecture).
- to provide mechanical attachment for the atrial and ventricular muscle.
- to maintain the cardiac position within the pericardium.
- to provide a stable but deformable base for the valvular fibrous cores.
- The aortic, and two atrioventricular valves are intimately interconnected through their basal collagenous frameworks. The pulmonary valve is remote from the others, being connected by the long deformable tendon of the conus arteriosus.

4. **Myocardial Architecture**:

Atrial fibres form two layers: superficial, common to both atria, and deep, confined to each. Ventricular fibres also consist of superficial and deep layers, where the deep layers also contribute to the papillary muscles. Current thinking regards the ventricular myocardium as a series of nested spiral laminae. These fibre-pathways have varying obliquity so that the myocardium is capable of reducing all the dimensions of the ventricles simultaneously.

II The pericardium

The **pericardium** is the membrane that lies in the middle mediastinum, posterior to the body of the sternum and the 2nd to 6th costal cartilages, and anterior to the 5th to 8th thoracic vertebrae. It consists of two opposed serous membrane surfaces: **parietal and visceral layers of the serous pericardium** forming a double-walled sac, which are separated by a film of fluid, the pericardial fluid. The outer serous layer lines the **fibrous pericardium**, a tough external sac, which blends with the great vessels and the fascia surrounding the trachea.

The pericardial cavity and the pericardial fluid allows for the pulsation of the heart without friction. The heart beats 70 – 80 times per minute and that for all our life until it stops in death. Two important **pericardial sinuses** may be identified when the serous pericardial sac is opened. Note the **transverse sinus**, a horizontal space within the pericardial cavity between the arterial and venous ends of the primitive heart tube. It can be demonstrated in between the aorta and pulmonary trunk anteriorly and the SVC and the left atrium with superior pairs of pulmonary veins posteriorly. Also note the **oblique sinus**, a cul-de-sac within the pericardial cavity bound anteriorly by the left atrium, posteriorly by the parietal pericardium and on the right by the pair of right pulmonary veins and the IVC and finally on the left by the left pairs of pulmonary veins. Developmentally the oblique sinus results during absorption of the pulmonary veins into the left

atrium and the reflection of the parietal pericardium. Functionally the oblique sinus permits for the pulsation of left atrium without friction.

Blood supply of the pericardium:

- Pericardiacophrenic branches from the internal thoracic artery in the neck (Internal thoracic artery is a branch of the subclavian a.).
- Brr from the musculophrenic artery (br of internal thoracic a.)
- Pericardial brr from the descending thoracic aorta and its branches (eg. bronchial, esophageal and superior phrenic).
- Note that the epicardium is supplied from the coronary arteries.

Venous drainage of the pericardium:

- To the azygos system of veins, which in turn drain to the superior vena cava.

Nerve supply of the pericardium:

Note that parietal pericardium is sensitive to pain. Generally the pain fibres from the fibrous and parietal pericardium travel with: phrenic n., from the vagus n., the sympathetic trunks. An inflammation of the pericardium is called the pericarditis.

Note that the epicardium or visceral pericardium is supplied from the cardiac plexus but is not sensitive to pain.

Lymphatic drainage of the heart:

The lymphatic vessels accompany coronary arteries and form two trunks. The right trunk ends in brachiocephalic nodes, which drain into right lymphatic duct. The left trunk ends in the tracheobroncheal lymph nodes at the bifurcation of trachea.

III Cardiac Surface Anatomy

- Cardiac apex corresponds approximately to the **apex beat**, which may be felt in the 5th left intercostal space in the midclavicular line. The apex beat is actually the lowest, most lateral point at which pulsation may be felt. The true cardiac apex is actually further inferolaterally and does not contact the thoracic wall in systole.
- Right border of the heart corresponds to a line from the right third costal cartilages superior border, 1.2 cm from the sternal margin to the 6th costal cartilage's junction with the sternum.
- the left border is marked by a line from the apex beat to the lower border of the left 2nd costal cartilage 1.2 cm from the sternal margin.
- see diagram for areas of surface projections of cardiac valves. Note that these are not the best areas at which to hear the corresponding valves.
- Areas for auscultation
    - mitral: Apex
    - tricuspid: Left sternal edge, 4th intercostal space.
    - aortic valve: 2nd right intercostal space
    - pulmonary valve: 2nd left intercostal space

IV Radiographs

- The cardiac borders in PA and lateral radiographs of the chest:
- The borders of the cardiac shadow in a **PA film** as seen from above downwards are: on the right side of the shadow - **right brachiocephalic vein**, **superior vena cava**, **right atrium**, **inferior vena cava**; on the left side of the shadow - **arch of aorta (aortic knuckle)**, **pulmonary trunk**, **left auricle**, **left ventricle**.
- In the lateral film the borders of the cardiac shadow are: anterior - **arch of aorta**, **auricles**, **right ventricle**; posterior: **left atrium**, **inferior vena cava**.

- In the angiograms and cardiac catheterization radiographs: identify the systole and diastole phases of circulation, the **pulmonary trunk, pulmonary arteries, right and left coronary arteries, branches of the arch of aorta, descending thoracic aorta and intercostal arteries**.

Materials: Articulated skeleton, **Prosected specimens:** Superficial and deep Thorax; wet specimens of dissected hearts; plastinated heart; **Models:** torso and heart models; **stethoscopes**, **radiographs**.

TUTORIAL/LABORATORY CLASS 6
THE BLOOD VESSELS, LYMPHATICS AND NERVE SUPPLY OF THORACIC VISCERA; CROSS SECTIONAL ANATOMY OF NECK AND THORAX

Aims: To describe the blood and nerve supply of the thoracic viscera. To understand the extrinsic and intrinsic nerve supply and to understand the basis of pain from the heart. It is suggested that the blood supply, nerve supply and lymphatic drainage of the thoracic wall should be learnt with the previous chapters on thorax, pleura and lungs. Some of the relevant topics have been brought forward, but there seems to be no need to repeat the information for the sake of completion of the lecture notes in this lab class. Students should be able to retrieve the required information from those topics as well as the recommended textbook.

Specific Objectives

1. To revise the arterial and venous drainage of the thorax. To revise the azygos venous system.
2. To describe the lymphatic drainage of the thoracic viscera.
3. To describe the arterial supply, venous drainage and lymphatic drainage of the lungs and pleura.
4. To revise the phrenic nerve and its distribution.
5. To describe the arterial supply and venous drainage of the heart, identifying the right and left coronary arteries and their branches (Left - 1st and 2nd diagonal, left diagonal, marginal, anterior interventricular and circumflex; Right - posterior interventricular, diagonal, marginal and nodal), the coronary sinus, great, small and middle cardiac veins and the posterior vein of the left ventricle, anterior cardiac veins.
6. To discuss the significance of the blood supply to the heart during diastole.
7. To describe the position of the sinoatrial node, the internodal pathways, atrioventricular node, atrioventricular bundle and its branches, and state their significance.
8. To summarize the role of the "afferent" innervation of the heart.
9. To describe the sympathetic and parasympathetic innervation of the heart.
10. To describe the position of the superficial and deep cardiac plexuses.
11. To describe the anatomical features of the cross sections of the head and neck.
12. To describe the anatomical features of the cross sections of the thorax.

Learning Activities

1. Revise the blood supply to the thoracic wall contributed by the **posterior** and **anterior intercostal arteries**.
2. Revise the **azygos venous system**. Identify the **azygos vein**, **hemiazygos vein**, and **accessory hemiazygos vein**.
3. It usually is hard to identify the lymph nodes in cadavers unless they are inflamed. The **bronchopulmonary** lymph nodes lie at the root of the lung. Discuss lymphatic drainage of the thorax with colleagues and your tutor. Note that the lymph from the thorax is collected by the right and left **bronchomediastinal trunks** (hard to see) and these in turn drain into the **right lymphatic duct** (easily removed during dissection of the root of neck but may be present in some specimens) and the **thoracic duct** respectively. Discuss the formation, tributaries and area of drainage by the right lymphatic duct and thoracic duct.

4. Identify the **coronary arteries** and their branches. Identify the **right coronary artery** and its branches: the **conus artery**, **atrial branches**; **right diagonal artery**, **right marginal artery**, **posterior interventricular artery**, **artery of the sinoatrial node** and the large **posterior septal artery**. There are also right posterior ventricular arteries (commonly two), which supply the diaphragmatic aspect of the right ventricle. Identify the **left coronary artery** and note that it divides into the **anterior interventricular artery**, the **circumflex artery**, and a **left diagonal artery**. The circumflex in turn gives rise to a branch (90% of hearts), which ramifies down the left margin of the heart, the **left marginal artery**. **Left atrial rami** can also be identified that supply the left atrium. The anterior ventricular artery gives off **first**, **second** and **third diagonal arteries**.
5. Identify the **cardiac veins** (**great, middle, small and anterior cardiac veins**) and **coronary sinus**. Remember that veins draining the heart may be divided into 3 groups: the **coronary sinus** and its tributaries; the **anterior cardiac veins**; and the venae cordis minimae. The **coronary sinus** lies in the posterior coronary sulcus and opens into the right atrium between the inferior vena cava opening and the right atrioventricular orifice. Its opening has a **valve of the coronary sinus** to prevent regurgitation of blood during atrial systole. It receives blood from the **great cardiac vein** (anterior interventricular vein, accompanying the anterior interventricular artery), lying in the anterior interventricular sulcus; the **small cardiac vein**, accompanying the right coronary artery lying in the posterior coronary sulcus between the right atrium and ventricle; and the **middle cardiac vein** (posterior interventricular vein, accompanying the posterior interventricular artery), lying in the posterior interventricular sulcus, the **posterior vein of the left ventricle**, lying to the left of the middle cardiac vein, and the oblique vein of the left atrium, which lies on the back of the left atrium. The **right marginal vein** courses along the right cardiac border and may drain into the right atrium, the anterior cardiac veins or the coronary sinus. **Anterior cardiac veins** are usually three in number and drain across the right ventricle into the right atrium. Venae cordis minimae are found in most chambers, but are rare in the left atrium and ventricle. They usually <u>cannot</u> be identified and open directly into the heart chambers.
6. Identify **right** and **left phrenic nerves** and their distribution.
7. Discuss the intrinsic nerve supply of the heart: the conduction system.
8. Identify the **extrinsic nerve supply of the heart**: the **superficial** and **deep cardiac plexuses**, the **pulmonary plexus** and the **esophageal plexus** in prosected specimens.
9. Discuss the **lymphatic drainage of the thorax**. Identify the **thoracic duct**, right lymphatic duct, and the bronchomediastinal trunks.
10. **Radiographs**: Identify the coronary arteries and their branches on coronary angiograms. Identify the systole and diastole in the cardiac catheterization radiograph.
11. To identify the major structures on the **cross sections** of the head, neck and thorax. It is not necessary to identify nerves, but knowledge of the course of major nerves such as the phrenic, vagus and recurrent laryngeal is important to interpretation of cross-sections.
12. To draw sections at the levels of: the oropharynx, **CV6**, **TV4**, **TV6**, and to label the visceral structures.
13. **Discuss clinical problems 20 and 21.**

Lecture Notes

1. The **coronary arteries** and their branches:

   The **right coronary artery** arises from the anterior (right by Nomina anatomica) aortic sinus, while the **left coronary artery** arises from the posterior (left by Nomina anatomica) aortic sinus. The right coronary artery reaches the right side of the atrioventricular (coronary) groove and travels to provide branches to supply the chambers of heart and terminates in the groove by anastomosing with the circumflex branch of the left coronary artery. Several **branches** are given off from this artery: the **conus artery**, which supplies the conus arteriosus; **atrial branches** (to right atrium); **right diagonal artery**, supplying the anterior aspect of the right ventricle; **right marginal artery**, supplying the lateral aspect of the right ventricle; **posterior interventricular/descending artery** (anastomoses with anterior interventricular branch of left

coronary artery at the apex of heart); **artery of the sinoatrial node** and the large **posterior septal artery** which supplies the atrioventricular node in 80% of hearts. There are also **right posterior ventricular arteries** (commonly two), which supply the diaphragmatic aspect of the right ventricle.

The **left coronary artery** supplies a *greater volume of the myocardium* than the right coronary artery. Left coronary artery passes behind the pulmonary trunk and then lies between the pulmonary trunk and the left auricle. While behind the auricle it divides into the **anterior interventricular/descending artery** (descending in the anterior interventricular groove and giving off the first, second and third diagonal branches); the **circumflex artery**, which curves to the left to lie in the coronary sulcus; and in 33-50% of hearts, a **left diagonal artery**, which courses across the anterior aspect of the left ventricle. The circumflex in turn gives rise to a branch (in 90% of hearts), which ramifies down the left margin of the heart, the **left marginal artery**. **Left atrial rami** can also be identified that supply the left atrium.

Concerning the areas of distribution:

The right coronary artery supplies all of the right ventricle (except a small region of the anterior interventricular sulcus), a variable part of the left ventricular diaphragmatic surface, the posterior inferior third of the interventricular septum, all of the right atrium, and part of the left, and the conducting system as far as the proximal parts of the right and left crura (see below). The left coronary is reciprocal in distribution.

Coronary artery dominance: is determined by the artery that gives rise to the posterior interventricular artery and supplies the AV node (normally it arises from the right coronary artery). However in 10% of population the right coronary artery is short and the posterior interventricular branch comes of as a direct continuation of the circumflex artery from left coronary artery.

Coronary anastomoses

These are of obvious clinical importance, but clinical experience suggests that anastomoses cannot rapidly provide collateral routes in the event of sudden obstruction of coronary arteries. These anastomoses are likely to be more effective in slowly progressive coronary obstruction. Anastomoses are said to be present throughout the cardiac wall thickness. Several extramural intercoronary anastomoses have been identified. These are:

a. the apex, between the anterior and posterior interventricular arteries
b. anterior aspect of right ventricle, between the anterior interventricular artery and right diagonal branches.
c. posterior aspect of the left ventricle, between the posterior interventricular and circumflex branches.
d. crux
e. interventricular sulci
f. interatrial sulci
g. between the sinuatrial nodal and other atrial branches.

Extracardiac anastomoses may connect the coronary arteries with other thoracic arteries via the pericardial arteries and arterial vasa vasorum of vessels linking the heart with systemic and pulmonary circulations. These are probably of no clinical significance however.

2. The **cardiac veins**. Veins draining the heart may be divided into 3 groups:

i) The **coronary sinus** and its tributaries, returning blood to the right atrium from the whole heart including the septa, except for the anterior region of the right ventricle and small parts of the left atrium and ventricle.

ii) The **anterior cardiac veins** draining blood from the anterior aspect of the right ventricle and a region around the right cardiac border where the right marginal vein joins this group. These veins end in the right atrium.

iii) The **venae cordis minimae**: opening into the right atrium and ventricle, and to a lesser extent, the left atrium and sometimes the left ventricle.

Coronary sinus and its tributaries:

The coronary sinus lies in the posterior coronary sulcus and opens into the right atrium between the inferior vena cava opening and the right atrioventricular orifice. Its opening has a valve of the coronary sinus to prevent regurgitation of blood during atrial systole. It receives blood from the following veins; all except the last have valves at their orifices:

- **Great cardiac vein** (anterior interventricular vein), lying in the anterior interventricular sulcus.
- **Small cardiac vein**, lies in the posterior coronary sulcus between the right atrium and ventricle and joins the coronary sinus near its atrial opening.
- **Middle cardiac vein** (posterior interventricular vein), lying in the posterior interventricular sulcus.
- **Posterior vein of the left ventricle**, lies to the left of the middle cardiac vein.
- Oblique vein of the left atrium, lies on the back of the left atrium. It is continuous above with the ligament of the left vena cava.

Anterior cardiac veins:

- Usually three in number.
- The **right marginal vein** courses along the right cardiac border and may drain into the right atrium, the anterior cardiac veins, or mostly drain into the small cardiac vein, or the coronary sinus.

Venae cordis minimae:

- Found in most chambers, but rare in the left atrium and ventricle. They open directly into the heart chambers.

3. **Nerve supply of the heart:**

The **intrinsic nerve supply** of the heart consists of the specialized cardiac muscle fibres for conducting electrical impulses. This constitutes the **pacemaker and conducting system of the heart**. Normal heart rate is 60 to 100 beats per minute.

The **sinuatrial node** is regarded as the initiator of each cardiac cycle. It lies at the superior limits of the crista terminalis in the wall of the right atrium. Variously described as a flattened ellipsoid, it is 10 to 20 mm in length, 1 mm thick and 3 mm at its maximum lateral convexity. It receives the large caliber artery of the sinuatrial node.

The sinuatrial node is said by some authors to be connected to the atrioventricular node (see below) by several internodal tracts. The anterior internodal tract (which includes the interatrial tract of Bachmann), the middle internodal tract, and the posterior internodal tract have all been claimed to exist on the basis of dissection and microscopy.

The **atrioventricular node** is oval (7 mm by 3 mm by 1 mm) and lies under the right atrial endocardium 1 cm above the septal margin of the orifice of the coronary sinus. Its anteroinferior end becomes the common atrioventricular bundle. The atrioventricular node is probably responsible for the atrioventricular conduction delay.

The **atrioventricular bundle** courses from the atrioventricular node along the postero-inferior margin of the membranous part of the interventricular septum to the muscular part of the interventricular septum. The bundle then divides: the **right branch** continuing subendocardially to the septomarginal trabecula, which it traverses to reach the base of the anterior papillary muscle of the right ventricle, and thence to the rest of the right ventricle; the **left branch** is actually several separate fascicles (separately ensheathed), which form a flattened sheet over the endocardium covering the muscular part of the interventricular septum and distributing to the left ventricle The **sinuatrial node** lies at the superior limits of the crista terminalis in the wall of the

right atrium. The **atrioventricular node** is oval and lies under the endocardium of the right atrium, 1 cm above the septal margin of the orifice of the coronary sinus. Its anteroinferior end becomes the common **atrioventricular bundle**. The **atrioventricular bundle** courses from the atrioventricular node along the postero-inferior margin of the membranous part of the interventricular septum to the muscular part of the interventricular septum. The bundle then divides into right and left branches: the **right branch** continues subendocardially to the septomarginal trabecula, which it traverses to reach the base of the anterior papillary muscle of the right ventricle. The **left branch** is actually several separate fascicles, which form a flattened sheet over the endocardium covering the muscular part of the interventricular septum and distributing to the left ventricle.

The **extrinsic nerve supply** of the heart is via the **cardiac plexuses**. The cardiac plexus is the autonomic plexus and consists of two parts. The **superficial cardiac plexus** lies below the arch of the aorta, anterior to the right pulmonary artery, near the ligamentum venosum. The **deep cardiac plexus** lies at the back of the aorta, in front of the tracheal bifurcation. The sympathetic component of the cardiac plexus contains preganglionic sympathetic fibres originating in T1 – T4 (T5) segments of the spinal cord. These postganglionic sympathetic fibres join the cardiac plexus. The preganglionic parasympathetic component of the cardiac plexus is contributed by both vagus nerves and the left recurrent laryngeal nerve. The effect of this plexus on the functional anatomy of the heart: the sympathetics are excitatory to the heart and parasympathetics are inhibitory to the heart.

Autonomic Nerve Supply to the Heart: Extrinsic Control

Sympathetic:

Contains afferent and efferent fibres.

i) Cardiac fibres from the superior, middle and inferior cervical ganglia (postganglionic fibres).

ii) Thoracic cardiac nerves: from T1 to 4 (T5) segments of the spinal cord (preganglionic) and thence via the sympathetic trunk as postganglionic fibres.

Afferent:

Pain sensory fibres probably pass back to the CNS with the sympathetic fibres (T1 to T4).

Parasympathetic:

Contains efferent and afferent fibres (preganglionic) as cardiac branches of vagus n. Sensory receptors in the atria and ascending parts of the great vessels (baroreceptors) send impulses via the vagus n. to the brainstem.

Vagus nerve CNX:

- Mixed nerve with sensory, motor and parasympathetic preganglionic.
- leaves the cranium via the jugular foramen, sharing an arachnoid and dural sheath with the accessory nerve.
- two ganglia, superior (jugular) and inferior (nodose), above and below the jugular foramen respectively. Both are exclusively sensory ganglia, containing somatic, special visceral and general visceral afferent neurons. Efferent fibres pass unsynapsed through the ganglia.
- The vagus descends vertically in the neck in the carotid sheath, between the internal jugular vein and the internal carotid artery to the thyroid cartilages upper border, and then passes between the vein and the common carotid artery to the root of the neck.
- Once in the thorax the courses differ according to side.

Right vagus nerve: descends posterior to the internal jugular v., passes through the superior mediastinum behind the Rt brachiocephalic v. It then passes behind the Rt principal bronchus to posterior aspect of Rt hilum to divide into posterior pulmonary plexuses, which unite with rami from the 2nd to 6th (7th) thoracic sympathetic. ganglia to form the pulmonary plexuses. Fibres descend from there to form (with Lt vagal ramus) the posterior esophageal plexus, which traverse

the diaphragmatic esophageal opening. In the abdomen it gives small gastric brr (to posterior-inferior stomach surface, except pylorus) and large coeliac brr (to form coeliac plexus).

Left vagus nerve: enters the thorax between the Lt common carotid and subclavian arteries. Divides into posterior pulmonary brr, which unite with rami of 2nd to 4th thoracic sympathetic trunk to form the posterior pulmonary plexus, two brr of which descend anterior to the esophagus as the anterior esophageal plexus. This passes through the esophageal opening to supply the cardiac portion of stomach, anterosuperior gastric surface, liver, pancreas, pylorus, superior and descending duodenum.

Branches

In the neck:

i) pharyngeal - to pharyngeal and palatal mm.

ii) brr to carotid body

iii) **superior laryngeal** - internal, external laryngeal N. branches

- internal - sensory to the laryngeal mucosa down to vocal folds.
- external - supplies inferior constrictor and cricothyroid.

iv) **recurrent laryngeal** - laryngeal mm, except cricothyroid, sensory to larynx below vocal folds, laryngeal stretch receptors.

v) **cardiac brr**

vi) anterior and posterior pulmonary brr

vii) esophageal, gastric, coeliac, hepatic and renal brr- to be dealt with later.

The above nerves form plexuses for cardiac supply:

i) superficial cardiac plexus (ventral) lies below the arch of the aorta, anterior to the right pulmonary artery, near the ligamentum arteriosum.

ii) deep cardiac plexus (dorsal) lies at the back of the aorta, in front of the tracheal bifurcation.

iii) left coronary plexus (accompanies the left coronary artery) receives branches from the deep plexus and supplies the left atrium and ventricle.

iv) right coronary plexus (accompanies the right coronary artery) receives the nerve fibres from the superficial and deep plexuses and gives branches to the right atrium and ventricle.

Function of the ANS supply to the heart

I) stimulation of the Vagus will:

- slow the heart
- reduce the blood pressure
- constrict the coronary arteries

II) stimulation of the sympathetic nerves will:

- raise the blood pressure
- raise the heart rate
- vasodailate the coronary arteries
- increase the force and speed of contraction of cardiac muscle.

4. **Venous drainage of thoracic cavity:**

The **azygos venous system**: The **azygos** vein is formed in the abdomen by the union of right subcostal vein and right ascending lumbar vein. The azygos vein enters the thoracic cavity accompanied by the thoracic aorta and the thoracic duct, by passing through the aortic hiatus in the diaphragm. Tributaries of azygos vein include 11 – 5 right posterior intercostal veins, right superior intercostal vein, hemiazygos and accessory hemiazygos veins.

The **hemiazygos** vein is similarly formed by the union of ascending lumbar and subcostal vein on the left side and enters the thoracic cavity by passing deep to the left dome of diaphragm. It receives 11 – 8 left posterior intercostal veins, crosses the vertebral column at the level of T8 vertebra to enter the azygos vein. The **accessory hemiazygos vein** is formed by the union of 5th,

6th and 7th left posterior intercostal veins, crosses the vertebral column at the level of T7 to enter the azygos vein. The azygos vein drains into the superior vena cava at the level of TV4.

5. **Lymphatic drainage of the thorax:**
   i) Lt and Rt bronchomediastinal trunks draining into the thoracic duct and the right lymphatic duct respectively.

   ii) parietal nodes:
   - diaphragmatic
   - parasternal
   - intercostal

   iii) visceral nodes:
   - pulmonary
   - bronchopulmonary
   - tracheobronchial (superior and inferior)
   - paratracheal
   - mediastinal

   The **Thoracic Duct**

   This is the largest lymphatic channel in the body (38 to 45 cm in length) and extends from the 1st lumbar vertebra to the root of the neck. It drains lymph from the left arm, left neck and head, left thorax, left upper abdomen (up to umbilicus), both sides of the abdomen below the umbilicus and both lower limbs. It arises either from the confluence of several lymph channels on the posterior abdominal wall, or in some individuals these lymph channels drain into a dilated sac known as the cisterna chyli, which lies anterior to the 1st and 2nd lumbar vertebrae. The thoracic duct then passes through the aortic opening in the diaphragm (TV 12), ascends in the posterior mediastinum to the right of the midline between the descending aorta (to its left) and the azygos vein (to its right). When it reaches the level of the TV5 it inclines to the left until it finally terminates either into the junction of the left internal jugular and subclavian Vs or one of those veins only. In 50% of people it has a terminal dilatation or **ampulla**. Before it terminates it receives the Lt jugular (draining lymph from left head and neck) and Lt subclavian (from left arm) trunks.

   It drains lymph from the entire body except the right head, neck, face, upper limb, and right side of the thoracic cavity.

   The **Right Lymphatic duct**

   On the right side of the body, lymph from the right head and neck, right arm, and right thorax and abdomen (down to the convex surface of the liver) are drained by the Rt jugular, Rt subclavian and Rt bronchomediastinal trunks respectively. In 20 % of people these join into a single channel, the Rt lymphatic duct, which drains into the junction of the Lt internal jugular and Lt subclavian vv or each of these veins separately.

Materials: **Prosected specimens:** superficial and deep thorax specimens, wet dissected hearts, plastinated hearts with good internal and external features; **Models**: Torso, heart models; **Radiographs**, angiograms.

APPENDIX 2
CARDIAC CLINICAL CONSIDERATIONS

Congenital heart disease

a. **Coarctation of Aorta**: there is a significant narrowing of the aorta, usually just below the origin of the left subclavian artery. The narrowed aorta is partially bypassed by a collateral circulation. Few patients with coarctation live beyond middle age. The optimum age for operation is between seven and fifteen years.

b. **Congenital aortic stenosis**: When the aortic valve orifice is reduced to about one quarter of its normal size, the flow of blood is so restricted that the left ventricular pressure begins to rise

above the aortic pressure. This is followed by hypertrophy of the left ventricle and finally heart failure. The narrowed aortic valve reduces the cardiac output, which cannot be increased to meet the demands of the body on exercise. This may lead to fainting on effort.

c. **Pulmonary valve stenosis**: the pressure rises in the right atrium and it can be a shunt of blood from the right to the left atrium through the foramen ovale and subsequent development of central cyanosis. The ECG shows evidence of right ventricular hypertrophy, and an X-ray shows diminished vascularity of the lung fields. Severe cases of pulmonary stenosis rarely reach middle age.

d. **Atrial and ventricular septal defect**: Atrioseptal defect is caused by abnormal development of septum secundum and foramen ovale. Half or more of the blood which enters the left atrium passes into the right atrium, right ventricle and thus back through the pulmonary circulation. On the radiographs of the chest there is marked dilatation of the pulmonary arteries and enlarged right ventricle. Ventricular septal defect: a small defect gives rise to no symptoms, the large defect causes a shunt of blood from the left ventricle to the right ventricle so that the pulmonary blood flow may be considerably larger than the systemic flow. Commonly the pulmonary hypertension develops and right and left ventricular hypertrophy.

e. **Fallot's Tetralogy**: It consists of a defect in the membranous part of the interventricular septum (VSD: ventricular septal defect), and stenosis (narrowing) of the pulmonary trunk of right ventricle. Hypertrophy of the right ventricle will occur due to pumping of the blood into a very narrow pulmonary trunk. Usually the blood is pumped to the pulmonary trunk and into aorta through the orifice formed over incomplete interventricular septum. Most of the venous blood will be pumped from the right ventricle into the aorta.

Ischaemic Heart Disease:

a. **Coronary artery disease:** starts with narrowing of the arteries by plaques. Obstruction of the blood flow becomes so severe that when exercise increases the oxygen consumption of the heart, not enough blood can pass through to supply it. The muscle, therefore, becomes ischemic and produces the characteristic pain of angina of effort. The next stage of the disease is the development of the thrombus, which cuts off the blood supply to an area of heart muscle and produces a cardiac infarct. This may be fatal, but often healing occurs with fibrosis and scar formation. The term coronary thrombosis and myocardial infarction are often used synonymously.

b. **Angina Pectoris** is characterized by substernal pain, which may radiate down the inside of the left arm, or both arms or up into the neck or jaw. It is brought on by effort and relieved within a few minutes by rest. It is more easily provoked in cold weather, after a heavy meal, or with emotional upset

APPENDIX 3
SURFACE ANATOMY OF NECK AND THORAX

Instructions: the surface/palpatory/living anatomy of the neck and thorax should be read by students and considered in their study of organs and structures of various systems. Unfortunately due to the shortening of the teaching period, this material no longer can be done at this point in the session as a learning activity. It will be covered in laboratory class 22.

A. NECK

1. **The common carotid artery** is covered almost completely by the sternomastoid muscle. Draw a line from the sternoclavicular joint up to the level of the upper margin of the thyroid cartilage where the common carotid divides into internal and external carotid arteries, the pulsations of which are felt below the angle of the mandible. Palpate the pulsation of the arteries and mark the level of the 4th cervical vertebra at which the common carotid artery bifurcates.
2. **The internal jugular vein** drains blood from the brain, superficial part of the face, and the neck. Its course corresponds to a line drawn from a point immediately below the external acoustic meatus to the medial end of the clavicle. Pulsations of the internal jugular vein resulting from constrictions of the right ventricle of the heart may be palpable and visible at the root of the neck. Because there are

no valves in the brachiocephalic vein or the superior vena cava, a wave of contraction passes up these vessels to the internal jugular vein. This systolic venous pulse is considerably increased in certain conditions (e.g. disease of the mitral valve leading to increased pressure in the pulmonary circulation).

3. **Cartilages of the Larynx.** Feel the thyroid cartilage, the prominence of which is the Adam's apple. Feel the lateral laminae of the thyroid cartilage. Below its lower edge, feel the cricoid cartilage, which is firm and rounded. Put your fingers gently down the midline and feel the tracheal rings in the suprasternal fossa. Grip the larynx between the fingers and thumb and observe the effect of swallowing. The muscles which elevate the larynx are: thyrohyoid, stylohyoid, mylohyoid, digastric, stylopharyngeus and palatopharyngeus. The depressors include the omohyoid, sternohyoid, and sternothyroid.

B. THORAX AND THE THORACIC CONTENTS

1. **Apertures of the Thorax**: Superior or thoracic inlet (5 cm antero-posteriorly and 10-11 cm transversely) is bounded by the body of the 1st thoracic vertebra, the medial border of the first ribs and their costal cartilages, and the superior part of the manubrium of sternum. Inferior or thoracic outlet is bounded by: the TV12, 12th pair of ribs, costal margins and the xiphisternal joint. Palpate the superior and inferior apertures and mark with a pencil.
2. **Thoracic vertebrae (TV):** Palpate and count the thoracic spines starting from the 7th cervical vertebra (vertebra prominens), which usually is the first prominent lump when palpating from above downward. Make it prominent by having the subject flex his neck. Spinous processes of TV1 to TV4 are easy to feel and see; those of TV5 - TV12 are much more difficult to palpate. Feel and mark the vertebral border of the scapula (TV2 - TV7 level).
3. **Sternum:** In the midline palpate the jugular notch at the upper end of the manubrium and between the sternal ends of the clavicle. The notch is usually at the level of the TV2 or TV3. Slide your finger down the midline for about 5cm and mark with a pencil the sternal angle (at TV4 or a disc between TV4 - TV5). It is an important landmark for the lower border of the superior mediastinum and for the level of the 2nd costal cartilage, the starting point from which the ribs should be counted. Palpate and mark with a pencil the xiphoid process lying in the bottom of the infrasternal fossa (epigastric fossa or 'pit of stomach'), at the level of TV9 or TV10.
4. **Ribs**: The first rib can be felt below and above the medial 1/3 of the clavicle. The other ribs may be palpated by: placing your fingertips in your axilla and slowly drawing them back inferomedially over your thoracic cage. Note that the spine of the scapula lies over the 3rd rib or 3rd intercostal space and the inferior angle of the scapula is at the level of the 7th rib and it is a good guide to the 7th intercostal space. The costal margins are palpable with ease. The highest part of the costal margin is formed by: the 7th costal cartilage and the lowest part by: the 10th costal cartilage. Anteriorly the ribs can be counted, starting from the sternal angle or 2nd costal cartilages, below which is the 2nd intercostal space.
5. **Diaphragm**: The level of the diaphragm on both sides varies in relation to the ribs and to the vertebrae according to the phase of respiration, posture and the degree of the distension of the abdominal viscera. The diaphragm is highest when the person is supine, lowest when the person is sitting or in an erect position (this explains why patients with difficulties in inspiration prefer to sit up rather than lie down). Mark with a pencil the domes of the diaphragm and the central tendon. In an erect position the right dome should be at the level of the 5th intercostal space in the midclavicular line, the central tendon at the xiphisternal junction, and the left dome at the level of the 6th costal cartilage.
6. **Trachea, Lungs and Pleurae:** The bifurcation of the trachea is at or below the sternal angle (TV5 or TV6) and slightly to the right. The bifurcation is not fixed and moves downward with respiration. Map the main bronchi obliquely downward for 2.5 cm.
7. The **pleural cavity** on each side surrounds a lung and is lined by parietal pleura. These two pleural cavities represent separate and closed potential spaces. The parietal pleura, which lines different parts of the thoracic wall and thoracic content can be divided into: (1) costal pleura, (2) mediastinal pleura, (3) diaphragmatic pleura and (4) cervical pleura. The apex of the lung is covered by cervical pleura (dome or cupola), which extends through the inlet of the thorax upwards to the neck of the 1st rib (level of the spine process of CV7). Because the 1st rib slopes downward, the lungs and the

pleura rise about 3 cm above the anterior end of the 1st rib and 1 to 2 cm above the middle third of the clavicle, behind the sternomastoid muscle.

8. The lines of **pleural reflection** are sites at which the costal pleura, becomes continuous with the mediastinal pleura anteriorly and posteriorly, and with the diaphragmatic pleura inferiorly. The sternal or anterior reflection: draw a line from the sternoclavicular joint to the median line at the level of the sternal angle. Then the right margin continues down to the xiphisternal joint, the left margin curves out from the 4th costal cartilage along the margin of the sternum to the 6th costal cartilage. The costal or inferior reflection is where the costal pleura is continuous with the diaphragmatic pleura near the costal margin. It passes obliquely across the 8th rib in the midclavicular line, the 10th rib in the midaxillary line and the 12th rib towards the spinous process of TV12.
9. **The Lungs:** the apex of the lung rises above the clavicle filling the cupola of the pleural sac. The anterior borders of the lungs follow the lines of pleural reflection, except for the anterior border of the left lung, which deviates about 2.5cm laterally from the left margin of the sternum to form the cardiac notch. The inferior border of both lungs crosses the 6th rib in the midclavicular line, 8th rib in the midaxillary line, 10th rib in the midscapular line and ends about 2.5 cm lateral to the spinous process of TV10 (6, 8, 10). During deep inspiration, the apparent level descends at least two intercostal spaces. The oblique fissure of the lung can be drawn on the surface of the thorax from a point about 2.5 cm lateral to the spinous process of the TV2 to the 6th costochondral junction (about 5 cm from the anterior median line). When the arm is abducted and the hand placed on the back of the head, the medial border of the scapula approximately indicates the oblique fissure. The horizontal fissure of the right lung is indicated by: a longitudinal line that runs from the anterior border of the lung along the 4th costal cartilage to the oblique fissure.
10. **The Heart**: The heart is located in the middle mediastinum, posterior to the body of the sternum and the 3rd to 6th costal cartilages, and anterior to the 5th to 8th thoracic vertebrae. Feel the apex beat in the 5th intercostal space (sometimes in the 6th) just medial to the midclavicular line. The position of the heart can be approximated on the chest by using three landmarks and your fingers: place a fingertip on the sternal angle, right end of the xiphoid process and the apex beat. This gives you a rough indication of the surface projection of your heart. Now, using a pencil, draw the outline of the heart: the right border: from the 3rd to the 6th costal cartilage, a finger's-breadth (a bit more than 1cm) from the right margin of the sternum; the inferior border: from the inferior end of the right border, through the xiphisternal joint to the apex beat; the left border: from the apex beat to the 2nd intercostal space, about a finger's-breadth from the left margin of the sternum; the superior border can be represented by a line joining the 2nd left intercostal space to the 3rd right costal cartilage. (Note that this method for the surface location of the heart applies only to a person lying in the supine position or to a cadaver. In the erect position the heart is slightly lower).

Physical examination of the chest

By **Inspection**: General contours of the chest, the respiratory movements, the apex beat, which may be visible, or other pulsations.

By **Palpation**: The position of the mediastinum can be assessed by determining the position of the apex beat and the trachea.

By **Percussion**: The percussion is conducted in the following manner: the middle finger of the left hand is placed firmly on the part, which is to be percussed. The middle phalanx of the middle finger of left hand is struck with the tip of the middle finger of the right hand. The stroke should be delivered from the wrist and the terminal phalanx should be perpendicular to the left middle finger. By percussion we can determine the boundaries between contiguous organs, and it should be performed from the resonant (e.g. lung) towards the less resonant (e.g. heart) organ. Normally the lungs are resonant to percussion and there are areas of dullness over the heart and liver. Impaired resonance is found over consolidated or collapsed lungs. The borders of heart: (inferior, left and right borders) may be determined by percussion and by this means the cardiac area (area of cardiac dullness) can be outlined.

By **Auscultation**: You will be using the stethoscope, which will amplify the sounds, which can be heard over the lungs and the heart. The breath sounds: characterized by long inspiratory phase followed by expiratory phase, which can be heard over the lungs. 'Bronchial' breathing (harsher quality) is heard by listening with a stethoscope over the larynx or trachea.

Heart sounds: are produced by valve closure:

- The **first sound** is caused by the closure of the tricuspid and mitral valves, and the second sound by the closure of the aortic and pulmonary valves. The first sound can be well heard at the apex (mitral valve) and over the lower part of the body of sternum (tricuspid valve). The first sound corresponds with the beginning of ventricular systole.
- The **second sound** at the right (aortic) and left (pulmonary) intercostal space. The second sound is sharper and shorter than the first and marks the beginning of ventricular diastole. In some abnormal conditions abnormal heart sounds can be heart. They may be caused by pathological narrowing of the valves (ex. mitral stenosis), incompetence of the valves, or by distension of the channels.

TUTORIAL/LABORATORY CLASS 7
THE MOUTH, TONGUE, PALATE AND PHARYNX

Aims: To understand the gross anatomy of mouth; the structure, muscles of tongue and palate and their innervation; and to revise the gross anatomy of the salivary glands in regards to their location, drainage and innervation.

Specific Objectives

1. To describe the boundaries and subdivisions of the oral cavity.
2. To identify the gross anatomy of tongue, including extrinsic and intrinsic muscles.
3. To describe the sensory and motor innervation of the tongue.
4. To summarise the lymph drainage of tongue.
5. To identify hard palate and soft palate and motor and sensory nerve supply of palate.
6. To identify the salivary glands, their ducts, openings, and anatomical relations.
7. To describe the secretomotor innervation of the salivary glands.
8. To identify hyoid bone, thyroid cartilage, cricoid & epiglottis cartilages in the neck.
9. To identify the three divisions of the pharynx, their boundaries, internal surface features. List the layers of the pharyngeal wall.
10. To identify the circular and longitudinal muscles of the pharynx and state their innervation.
11. To describe roles of the tongue, palatal and lip musculature in swallowing.
12. To summarise the sensory innervation of the pharynx.

Learning Activities

1. **Oral cavity:** On prosected specimens identify the **oral cavity,** its parts, and their boundaries. The oral cavity is divided into two parts, the **vestibule** and the **oral cavity proper** and the two parts of the oral cavity communicate with each other behind the molar teeth. The **oral cavity proper** is bounded anterolaterally by the **superior** and **inferior alveolar arches**, teeth and gums; posteriorly, it communicates with the pharynx via the **oropharyngeal isthmus**. Identify the roof that is formed from the **hard and soft palates**; and most of its floor by the anterior region of the tongue and the remainder by the reflection of the mucosa from the inferior surface of the tongue to the internal surface of the mandible. Identify the **vestibule** bound anteriorly by the lips, (which are covered by skin externally and by mucous membrane internally); laterally by the cheek; and medially by the teeth and gums. Note that the following muscles form the floor of the mouth: from above downwards: geniohyoid, mylohyoid (diaphragma oris), anterior belly of the digastric, and stylohyoid. On each side a **labial commissure** forms the angle of the mouth. Externally and central in the upper lip is a shallow vertical groove, the **philtrum**, ending below in a slight tubercle. Internally, each lip is connected to the gum by a median **labial frenulum**.

2. **Tongue:** Examine the surface features and parts of the tongue and identify **root**, **apex**, curved **dorsum** and inferior surface. Its dorsum consists of **oral/presulcal** and **pharyngeal/postsulcal** parts, separated by the **sulcus terminalis**, a V-shaped groove running from the **foramen caecum** medially to the bases of the **palatoglossal arches** laterally. Note that the surface of the tongue is rough due to the presence of the taste buds.

   Identify the external surface features of the tongue: **foramen caecum**; **median sulcus** that extends from the **median glosso-epiglottic fold** posteriorly to the **apex** of the tongue anteriorly and

overlies the median septum internally; **lingual tonsil** (is the postsulcal or pharyngeal part of the tongue); **epiglottic vallecula** between the **median** and **lateral glosso-epiglottic folds** attaching the postsulcal part of the tongue to the epiglottis; and the **fungiform, filliform, foliate** and **circumvallate** lingual papillae on the dorsum of the tongue.

Muscles of tongue: Identify the intrinsic and extrinsic muscles of the tongue and discuss their innervation.

Identify the **extrinsic muscles of the tongue**: the **hyoglossus**, **genioglossus**, **styloglossus** & **palatoglossus** muscles and study their attachments & action.

Identify the **intrinsic muscles of the tongue** that are used to change the shape of the tongue: **transverse**, **vertical**, **superior** and **inferior longitudinal** muscles.

Nerve supply of the tongue: Identify the sensory and motor innervation of the tongue. All the muscles of the tongue (except palatoglossus) are supplied by **hypoglossal nerve (CNXII)**. Identify the **lingual**, and **chorda tympani** in the prosected specimens.

*Discuss general and taste related sensory innervation of the anterior 2/3rd and posterior 1/3rd of the tongue. Why is posterior part of the tongue called **lingual tonsil**? Deduce functional roles of the tongue and effects of lesion of hypoglossal nerve. Participate in a tutorial discussion of the lymphatic drainage of the tongue. Deduce the effects of hypoglossal nerve section. Deduce the functional roles of the tongue.*

3. **Palate**: Identify the bones contributing to the formation of **hard palate**. The bony palate consists of: i) **palatine process of maxilla**, joined by **intermaxillary suture**. Anterior to this suture lies the **incisive foramen**, with orifices of two **incisive canals**, transmitting terminations of greater palatine artery and nasopalatine nerve. ii) **horizontal plate of palatine**, at the lateral edge of which, between maxilla and palatine bones, lies the **greater palatine foramen** and more posteriorly lies the **lesser palatine foramen**. Identify the **soft palate**, **uvula**, **palatoglossal** and **palatopharyngeal arches**. *What is the oropharyngeal isthmus and what are the pillars of fauces?*

4. **Palatine tonsil**: Identify the **palatine fossa** containing the **palatine tonsil**. The **palatine aponeurosis** (thin and fibrous) supports the muscles and strengthens the soft palate. It attaches to the posterior border and inferior surface of the hard palate. Examine the prosected specimens and identify the **muscles** of the palate: **palatoglossus**, **palatopharyngeus**, **musculi uvulae**, **tensor veli palatini** and **levator veli palatini**. Deduce the actions of these muscles and note all muscles of the palate (except tensor veli palatini) are supplied by the pharyngeal plexus. *What is the pharyngeal plexus? What is the innervation of tensor veli palatini? What are the immediate relations of the palatine tonsil? What branch of the external carotid a. provides main blood supply to the palatine tonsil? Revise the roles of the tongue, palatal and lip musculature in **speech**.*

5. **Salivary glands**: Identify three pairs of salivary glands: **parotid**, **submandibular** and **sublingual gland**. Note that the duct of parotid gland opens in the vestibule of mouth opposite the upper second molar tooth. Note the immediate relations of the parotid gland: the **parotid bed**. *What structures are embedded within the substance of the parotid gland? Where do the ducts of the submandibular and sublingual salivary glands open? What is the relationship of the submandibular duct to the lingual nerve?*

6. **The nerves of the oral cavity**, **salivary glands,** and **palate (CNV**, **CNVII**, **CNIX**, **& CNXII, pharyngeal plexus)**: D*iscuss the functional components of these nerves in relation to the oral cavity, salivary glands and pharynx. Discuss the effects of damage to these nerves. Discuss the action of the autonomic nerves on the function of salivary glands.*

7. **Pharynx:** Identify on the **base of skull**: **pterygoid hamulus** that comes off from the **medial pterygoid plate**, **choana**, **pharyngeal tubercle of occipital bone** and **styloid process of temporal bone**. Identify the **groove for auditory tube**, which gives attachment to the cartilagenous part of the auditory tube.

   Identify the three divisions of the pharynx: the **nasopharynx**, **oropharynx** and **laryngopharynx**. Examine the internal features of the pharynx. List the layers of the pharyngeal wall and identify the

layers of the pharyngeal musculature including circular muscles: the **superior, middle and inferior constrictor** muscles and longitudinal muscles: the **salpingopharyngeus, palatopharyngeus and stylopharyngeus** muscles.

Examine the **internal features of the pharynx**:

The **nasopharynx:** the **pharyngeal isthmus** (bounded by soft palate and posterior pharyngeal wall), on the lateral wall of the nasopharynx the **pharyngeal opening of the auditory tube**, bound above and behind by a **tubal elevation**. Identify the **salpingopharyngeal fold**. *What structure forms this fold?* Identify the **pharyngeal recess**. The pharyngeal tonsil, a lymphoid tissue called the adenoids when enlarged lies in the submucosa of the posterior wall. *What is the clinical importance of adenoids?*

The **oropharynx:** identify the palatoglossal and palatopharyngeal arches and the tonsillar fossa within the two folds.

The **laryngopharynx:** identify the **laryngeal inlet**, bounded laterally by the **aryepiglottic folds**. On either side of the laryngeal prominence of the laryngopharynx identify the **piriform recess**. The laryngopharynx continues inferiorly as the esophagus at the lower border of cricoid cartilage (CV6).

Nerve supply of pharynx: In summary the nerves associated with pharynx include: **Maxillary nerve (CNV)**, **Glossopharyngeal nerve (CNIX)**, **Vagus (CNX)**, and **Pharyngeal plexus.** Participate in the tutorial discussion of the glossopharyngeal nerve, including its distribution, its parasympathetic contribution to the otic ganglion and effects of lesion of this nerve. On the prosected specimens and models identify the glossopharyngeal nerve. **Vagus nerve (CNX)**: On the prosected specimens, follow the course of the vagus nerve and identify branches in the neck. Identify the **superior laryngeal nerve,** which divides into the **internal** laryngeal branch (sensory) and the **external** laryngeal branch (motor). Note that these branches will be covered in second year. Locate the **recurrent laryngeal nerve** (sensory & motor) in the groove between the trachea and the esophagus. Note the course and relationships of the right and left recurrent laryngeal nn. *What nerve is vulnerable to injury in the piriform recess and why?*

8. *Describe the process of **swallowing**.*

9. **Discuss clinical problem 4.**

Lecture Notes

1. **Mouth and Oral Cavity**:

The Mouth: is the first part of the digestive system. It consists of a small **vestibule** outside the teeth and a much larger, inner **oral cavity proper**. The mouth communicates with the exterior via the **oral fissure**. The oral cavity proper is bounded anterolaterally by the **alveolar arches**, teeth and gums; behind it communicates with the pharynx via the **oropharyngeal isthmus**. Its roof is formed from the **hard and soft palates**, most of its floor by the anterior region of the tongue and the remainder by the reflection of the mucosa from the tongue's inferior surface to the internal mandibular surface.

The vestibule: bounded by the lips, which are covered by skin externally and by mucous membrane internally. On each side a **labial commissure** forms the angle of the mouth. Externally and central in the upper lip is a shallow vertical groove, the **philtrum**, ending below in a slight tubercle. Internally, each lip is connected to the gum by a median **labial frenulum**. The orbicularis oris muscle lies between the two surfaces (CN VII). **Labial glands** are situated between the mucosa and the orbicularis oris; their ducts opening into the vestibule. Sensory nerves supplying the lips are the infraorbital nerve (maxillary division of the trigeminal nerve) and the mental nerve (mandibular division of the trigeminal nerve).

The cheeks: lateral wall of the vestibule of the mouth. Covered externally by fascia and the **buccal fat pad**. Contains the opening of the parotid duct opposite the crown of the 2nd upper molar. The principal muscle is the buccinator, but zygomaticus major, risorius and platysma also contribute (all CNVII).

The gums (**gingivae**): fibrous tissue covered by mucous membrane and attached to margin of alveolar processes of maxilla and mandible, and to the neck of teeth. Gums attach to enamel in young people, but recede with advancing age to attach to the cementum.

Nerve supply of gums:

- Teeth and gums of upper jaw: anterior palatine, nasopalatine and anterior, middle, and posterior superior alveolar brr of the maxillary division of CNV.
- Teeth and gums of lower jaw: inferior alveolar, lingual and buccal brr of the mandibular division of CNV.

2. **The tongue**: Is a highly muscular organ of deglutition, taste and speech. It is attached to the hyoid bone, mandible, styloid process of temporal bone, soft palate and pharyngeal wall. The surface features and parts of the tongue include: **root**, **apex**, curved **dorsum** and inferior surface. Its dorsum consists of **oral** (**presulcal**) and **pharyngeal** (**postsulcal**) parts, separated by the **sulcus terminalis**, a V-shaped groove running to the bases of the **palatoglossal arches**. Note that the surface of the tongue is rough due to the presence of the taste buds.

   Features of the tongue on the **dorsum**: **foramen caecum**, a **median sulcus**, extending from the **median glosso-epiglottic fold** to the **apex** of the tongue, a **lingual tonsil** (in the postsulcal part), consists of multiple lymphoid nodules embedded in the submucosa, an **epiglottic vallecula**, between the median and **lateral glosso-epiglottic folds** in the postsulcal part, **foliate** and **vallate lingual papillae**.

   The **filiform** - small, conical or cylindrical, arranged in rows parallel to vallate papillae. Cover most of the presulcal part of the dorsum. Do not bear taste buds, but increase friction.

   The **vallate** (**circumvallate**) papillae: 8 to 12 in number. Arranged in front of sulcus terminalis (V-shape). One to two mm in diameter, consist of papilla surrounded by sulcus, which is in turn surrounded by a wall (vallum). Taste buds lie in both sulcal walls.

   The **fungiform**: occur mainly on the lingual margin. Large round shape, deep red colour and bear taste buds.

   The **foliate**: grooves and ridges at the lateral margins of the tongue near the palatoglossal arch. Contain taste buds.

   Features of the **inferior** surface: **frenulum** of the tongue connecting the tongue to the floor of mouth, **profunda linguae veins** visible on either side of the frenulum, and paired **plica fimbriata**, a fold of mucous membrane with unknown significance, lying on the lateral side of the vein. The lower end of the frenulum presents an elevation, the **sublingual papilla**, on which the submandibular duct opens. Note also on the floor of the mouth, the **sublingual fold** - produced by the sublingual gland, which contains openings of sublingual ducts.

   Muscles of the tongue:

   Intrinsic: alter the shape of the tongue. All are supplied by CN XII.

   - **Superior and inferior longitudinal**: shorten the tongue. Superior longitudinal also turns the apex and sides upwards, and the inferior longitudinal also turns the apex down.
   - **Transverse**: narrows and elongates the tongue.
   - **Vertical**: makes tongue flatter and wider.

   Extrinsic: alter the position of the tongue and stabilize the tongue.

   - **Genioglossus**: attaches to the superior genial tubercle behind the mandibular symphysis. Acts to produce protrusion of the tongue (CNXII).
   - **Hyoglossus**: attaches to the whole length of the greater cornu and front of the body of the hyoid. Acts to depress the tongue (CNXII). Chondroglossus muscle sometimes described, may be part of hyoglossus.
   - **Styloglossus**: from styloid process near apex. Acts to retract tongue (CNXII).
   - **Palatoglossus**: from palatine aponeurosis to form palatoglossal arch. Acts to raise the

tongue (CNX, via pharyngeal plexus; fibres actually leave brainstem in the cranial root of accessory).

Accessory:

- **Mylohyoid**: raises floor of mouth (CNV)
- **Geniohyoid**: shortens floor of mouth (C1 via ansa cervicalis)
- **Ant. & post. belly of digastric:** depress mandible (CNVII)
- **Stylohyoid**: elongates floor of mouth (CNVII).

Nerve supply of the tongue: Each half of the tongue receives its innervation from the following nerves/plexuses.

Motor innervation of the tongue:

All the intrinsic and extrinsic muscles of tongue except for the palatoglossus are supplied by Hypoglossal nerve (CNXII). Palatoglossus is supplied by the pharyngeal plexus (CNIX, CNX, CNXI).

Sensory innervation of tongue:

a) Oral part: **lingual nerve** (from mandibular division of CNV) for general sensation and **chorda tympani** (from CNVII) for taste.

b) Pharyngeal part and vallate papillae: lingual branch of the **glossopharyngeal n**. for both taste and general sensation. Near the epiglottis the internal laryngeal branch of the vagus provides general sensation and taste.

Blood supply of tongue:

Tongue (each half) is supplied by ascending pharyngeal, lingual, facial and maxillary branches of the external carotid arteries.

3. **The Palate**: consists of **hard palate** and **soft palate** covered by mucosa

Hard/Bony palate consists of:

a. **Palatine process of maxillae** joined by **intermaxillary suture**. Anterior to this suture lies the **incisive foramen**, with orifices of two **incisive canals**, transmitting terminations of greater palatine artery and nasopalatine nerve.

b. **Horizontal plate of palatine**, at the lateral edge of which, between maxilla and palatine bones, lies the **greater palatine foramen** (transmits the greater palatine vessels and nerve). More posterior lies the **lesser palatine foramen** for the corresponding nerves and arteries.

The Soft Palate*:*

Is suspended from the hard palate. It acts as a partition between the nasopharynx and the oropharynx and possesses a median conical process, **the uvula**, from its posterior edge. Two curved folds of mucosa containing muscle extend laterally from the base of the uvula: palatoglossal arch, palatopharyngeal arch. The **palatine fossa** lies between these two arches and contains the **palatine tonsil**. Attached to the posterior edge of the hard palate is the **palatine aponeurosis** (thin and fibrous) that supports the muscles and strengthens the soft palate. It attaches to the posterior border and inferior surface of the hard palate. It thins as one proceeds posteriorly and encloses the uvulae muscle in the midline.

Muscles of the soft palate:

a. **Palatoglossus**: from palatine aponeurosis to posterolateral part of the tongue. Forms the palatoglossal arch by raising the oral mucosa. Action: elevates the root of the tongue and approximates palatoglossal arches to close of oropharynx from oral cavity. Nerve supply: cranial accessory via vagus to pharyngeal plexus.

b. **Palatopharyngeus**: from hard palate and palatine aponeurosis to the posterior border of the thyroid cartilage. Forms the palatopharyngeal arch by raising pharyngeal mucosa.

Action: pulls the pharynx up, forwards and medially, shortening it during swallowing. Also approximates the palatopharyngeal arches. Nerve supply: as for palatoglossus.

c. **Musculus uvulae**: attached to the posterior nasal spine of the palatine bone and the palatine aponeurosis, descends to insert in the uvular mucosa. Action: elevates and retracts the uvula. Nerve supply: as for palatoglossus.

d. **Levator veli palatini**: from petrous part of the temporal bone and cartilage of the auditory tube, to upper surface of the palatine aponeurosis. Action: elevates the soft palate. Nerve supply: as for palatoglossus.

e. **Tensor veli palatini**: attaches to the scaphoid fossa of the pterygoid process, spine of the sphenoid and the auditory tube. It attaches to the palatine aponeurosis. Action: alone, pulls the soft palate to one side; together, tauten and depress the soft palate. Nerve supply: mandibular division of the trigeminal.

Movements of the Palate: Essential to swallowing, blowing and speech: all require variable degrees of closure of the pharyngeal isthmus.

- Closure is maximal during oral blowing to prevent escape of air through the nose.
- In deglutition (swallowing) closure of nasopharyngeal isthmus prevents regurgitation into the nasopharynx.
- In speech closure is maximal in the production of explosive consonants e.g. ***b*** and ***p***.
- Closure itself is produced by levatores veli palatini pulling the soft palate up and back towards the posterior pharyngeal wall while the palatopharyngeal sphincter raises the wall to meet the palatine nasopharyngeal surface.

4. **Salivary Glands:**

The oral cavity receives saliva from three main pairs of salivary glands: the parotid, submandibular and sublingual. In addition there are many small glands, which may be found scattered in the oral cavity.

The parotid gland: The parotid gland is the largest salivary gland, which secretes watery saliva. It is located in the space, which is also referred to as the **parotid bed**. The parotid bed is bound: laterally by the external acoustic meatus and anteriorly by the ramus of mandible with masseter muscle. The parotid gland inferior to mandible lies superficial to the sternoceidomastoid muscle. The gland is related medially to the pharyngeal wall and the anterior margin of the gland extends superficial to the masseter muscle. Arising from the anterior margin of the gland is the parotid duct which takes a sharp, deep and medial turn, pierces the buccinator muscle and enters the vestibule of oral cavity opposite the upper second molar tooth. The parotid gland is enclosed within a layer of very strong deep fascia, which distally becomes continuous with the investing layer of the deep fascia of the neck. The parotid gland is divided into ***superficial*** and ***deep*** portions by the facial nerve. In addition to the facial nerve the gland also contains from superficial to deep: the formation and termination of the retromandibular vein and the external carotid artery and its division into maxillary and superficial temporal arteries. It also contains branches of auriculotemporal nerve, which supply the gland and the parotid lymph nodes.

Nerve supply of parotid gland:

The preganglionic parasympathetic fibres travel via the tympanic branch of the glossopharyngeal nerve, enter the middle ear cavity and join with branches of the facial nerve to form a tympanic plexus over the promontory on the medial wall. The plexus gives rise to the lesser petrosal nerve, which exits from the middle ear cavity and passes through foramen ovale to enter the ***otic ganglion***. The lesser petrosal nerve synapses in the otic ganglion and the postganglionic secretomotor fibres join the auriculotemporal branch of the mandibular nerve to supply the parotid gland. The postganglionic sympathetic fibres reach the gland from T1 via superior cervical ganglion and then the plexus around middle meningeal artery (from maxillary branch of

the external carotid artery). The sensory nerve supply to the gland comes from the auriculotemporal nerve.

Lymphatic drainage of parotid gland:

The lymph from the parotid gland drains into the parotid lymph nodes and then to the deep cervical group of lymph nodes.

The submandibular gland: The submandibular gland has mixed serous and mucous secretion but it is mainly watery. As the name suggests the gland is located under the lower border of body of the mandible and is enclosed within the layers of the deep fascia of the neck. The gland has *superficial* and *deep* portions related to the mylohyoid muscle in the floor of the oral cavity. The two portions of the gland are continuous around the lateral border of the mylohyoid muscle. The submandibular duct arises from the anterior end of the deep portion of the gland and is crossed laterally by the lingual nerve. The duct travels under the mucus membrane of the mouth and opens in the oral cavity proper on the summit of an elevation called the *papilla*, which is situated lateral to the frenulum of the tongue.

The sublingual gland: The sublingual salivary gland is located in the sublingual fossa on the internal surface of the mandible. The gland lies deep to the mucous membrane of the sublingual fold at the side of the tongue within the oral cavity proper. Even though the secretions of the gland are mixed but the gland is mainly responsible for thick, stringy and mucoid secretions. The secretions are carried to the floor of the oral cavity proper by over a dozen (8-20) ducts, which open on the surface of the sublingual fold in oral cavity proper.

Nerve Supply of submandibular and sublingual salivary glands:

The preganglionic parasympathetic fibres travel via the chorda tympani branch of the facial nerve, which arises in the middle ear cavity as the facial nerve travels in the facial canal, it then exits from the middle ear cavity and passes through the petrotympanic fissure at the base of the skull. The chorda tympani nerve joins the lingual branch of the mandibular nerve in the infratemporal fossa, and travels within the same fascial sheath of the lingual nerve. These preganglionic fibres enter the ***submandibular ganglion***, which hangs from the lingual nerve; the postganglionic fibres supply secretomotor fibres to the submandibular gland. Some of the postganglionic fibres join back the lingual nerve and are carried to the sublingual gland. The postganglionic sympathetic fibres reach the gland from T1 via superior cervical ganglion and then the plexus around facial (lingual) artery a branch of the external carotid artery. The sensory nerve supply to the gland comes from the lingual nerve.

Lymphatic drainage of submandibular and sublingual salivary glands:

The lymph from the sublingual and submandibular gland drains into the submandibular group of lymph nodes and then to the deep cervical group of lymph nodes.

5. **The pharynx:**

Pharynx is a fibromuscular tube that forms a common channel for both the food and air and hence it constitutes to be a part of the respiratory and digestive system. The pharynx has *three* parts: **nasopharynx**, **oropharynx** and **laryngopharynx**

a) **<u>Nasopharynx</u>**:

- Extends from the posterior nasal apertures or the choanae to the lower border of uvula and lies posterior to nasal cavities and superior to soft palate.
- Communicates with the oropharynx by the **pharyngeal isthmus.** Note that pharyngeal isthmus is bound anteriorly by soft palate and posteriorly by the posterior pharyngeal wall. It closes during swallowing by elevation of the soft palate and contraction of the palatopharyngeus muscle.
- Each lateral wall possesses the **pharyngeal opening of the auditory tube**. This opening is bound superiorly and posteriorly by a comma-shaped swelling called **torus tubarius** or **tubal elevation**.

- A vertical **salpingopharyngeal fold** of mucous membrane descends from the tubal elevation and is formed by the **salpingopharyngeus** muscle.
- **Pharyngeal recess** lies posterior to the tubal elevation.
- The **pharyngeal tonsil**, a lymphoid tissue, lies in the submucosa of the posterior wall.

b) **<u>Oropharynx</u>**:

- Extends from soft palate to the upper border of the epiglottis and is the smallest part of pharynx.
- Lateral wall of oropharynx consists of the **palatopharyngeal** and **palatopharyngeal arches** and the **palatine tonsil** in the **tonsillar fossa/sinus** between the arches. The tonsillar fossa or sinus is located behind the 3rd lower molar tooth. The palatine tonsil is the chief component of **Waldeyer's ring**. The Waldeyer's ring comprises of groups of lymphoid tissue formed by: lingual, palatine, tubal and pharyngeal tonsils on each side and it provides a protective annulus around the entrance to the digestive and respiratory tracts, providing humoral and cellular defense against infection traveling from the oral and nasal cavities to the pharynx.

c) **<u>Laryngopharynx</u>**:

- Extends from the cranial border of the epiglottis (lower CV 3 body) to the inferior border of the cricoid cartilage (upper CV 6 body), where it becomes continuous with the esophagus.
- Anterior wall contains the **laryngeal inlet**, bounded laterally by the **aryepiglottic folds**. On either side of these in turn lie the **piriform fossae**. Foreign bodies may lodge in the piriform fossa. The **internal laryngeal nerve** (to be discussed later) lies beneath the mucosa in the fossa, where it may be damaged during removal of foreign bodies.

Structure of the pharynx*:* Several layers of its wall are described from within outside:

- Mucous membrane
- Fibrous coat - **pharyngobasilar fascia** above is very thick (attaches to the basilar occipital and petrous temporal bones, medial pterygoid plate and **pterygomandibular raphe**) descends, thinning as it goes, to become the internal epimysium of the pharyngeal muscles.
- Muscular coat:
    - External layer is made of circular muscle fibres- **superior, middle and inferior constrictors of the pharynx**.
    - Internal layer is made of longitudinal muscle fibres- **stylopharyngeus, palatopharyngeus and salpingopharyngeus** mm.
- Thin **buccopharyngeal fascia** passing forwards to the buccinator muscle.

Muscles of the Pharynx*:*

The constrictors or external circular layer:

- **Inferior pharyngeal constrictor** has two parts: the **cricopharyngeus** ("sphincteric") and **thyropharyngeus** ("propulsive") mm. Arises from the thyroid and cricoid cartilages passing posteriorly to insert in the **median pharyngeal raphe**.
- **Middle constrictor** attaches to: lesser horn of the hyoid and lower part of the stylohyoid ligament, inserting posteriorly into the median pharyngeal raphe.
- **Superior constrictor** attaches to: **pterygoid hamulus**, pterygomandibular raphe and posterior end of the mylohyoid line of the mandible. It attaches medially to the median pharyngeal raphe. The **pterygomandibular raphe** is a strand of tendinous tissue passing from the pterygoid hamulus to the posterior end of the mylohyoid line of the mandible.

Internal longitudinal layer:

- **Stylopharyngeus**: from base of styloid process to posterior border of thyroid cartilage and the constrictors (merges with fibres).
- **Salpingopharyngeus**: from the inferior part of the cartilage of the auditory tube to blend

with the palatopharyngeus.

- **Palatopharyngeus**: from hard palate and palatine aponeurosis to the posterior border of the thyroid cartilage.

Blood supply of the pharynx:

- Ascending pharyngeal aa. (br of external carotid)
- Palatine aa (brr of facial a.)
- Tonsilar aa (brr of facial a.)
- Palatine and pharyngeal brr of the maxillary a.

Nerves of the pharynx:

- Motor (somatic): to most muscles: from pharyngeal plexus located on the middle constrictor muscle, cranial part of the accessory via vagal branches; stylopharyngeus is supplied by CNIX.
- Autonomic: from the superior cervical ganglion (sympathetic) and vagus (parasympathetic secretomotor).
- Sensory: the nasopharynx is supplied by brr of maxillary N (CNV, via pterygopalatine ganglion); the oropharynx by CN IX and laryngopharynx by CNX.

6. **Palatine tonsil**: The palatine tonsils lie in the oropharynx in the tonsillar fossa in between the palatopharyngeal and palatoglossal arches. Tonsillitis is a disease of the childhood and it results into the enlargement of the palatine tonsils causing difficulty in swallowing and fever. The lymphatics from the tonsils pass through the superior constrictor to the **jugulodigastric** (**tonsillar**) node at the angle of the jaw. Note that tonsils have a rich vascular supply.

7. **Deglutition: (swallowing)**

Definition: Diglutition or swallowing is the process of passage of food from the mouth, through the pharynx and esophagus into the stomach. It is divided into three stages depending on their voluntary or involuntary controls.

Stage I: (Voluntary)

- Anterior part of the tongue is raised and pressed against the hard palate by action of the intrinsic muscles (especially the superior longitudinal and transverse). A bolus of food is formed behind the apex of the tongue and pushed backwards.
- Soft palate descends onto the lingual dorsum (palatoglossus), helping to grip the bolus of food.
- Simultaneously the hyoid bone is elevated and moved forwards by the action of the geniohyoid, mylohyoid, digastric and stylohyoid mm.
- The postsulcal part of the tongue is drawn up and back by the styloglossus muscle and the palatoglossal arches are approximated by the palatoglossal mm, pushing the bolus through the oropharyngeal isthmus into the oropharynx where the second stage begins.

Stage II: (Involuntary)

- Soft palate is elevated (levator mm), tightened (tensor mm) and firmly approximated to the posterior pharyngeal wall by the palatopharyngeal sphincter and the upper part of the superior constrictor of the pharynx.
- The pharyngeal isthmus closes to prevent food from ascending into the nasopharynx.
- Larynx and pharynx are drawn up behind the hyoid bone by the stylopharyngeus, salpingopharyngeus, thyrohyoid and palatopharyngeus mm.
- Simultaneously the aryepiglottioc folds are approximated, excluding the bolus from the larynx.
- By gravity and the contractions of the superior and middle constrictors of the pharynx, the bolus slips over the epiglottis (which is bent backwards over the laryngeal opening) and the laryngeal opening into the lowest part of the pharynx.
- The palatopharyngeus mm help to shorten the pharynx make the posterior pharyngeal wall into an inclined plane directed posteroinferiorly which forces the bolus down.

Stage III: (Involuntary)

- This involves the expulsion by the inferior constrictor of the compressed bolus into the esophagus, where peristalsis forces the bolus down to the stomach.

8. **Surface Anatomy**:
   - On a colleague, using a torch and tongue depressor, examine the tongue and the oral cavity. Observe the **frenulum** of the **upper lip**, a median fold of mucosa connecting the deep aspect of the lip to the upper gum. Note the **frenulum** of the **lower lip**, a similar fold. Note the soft mucosa of the cheeks, floor of the mouth and soft palate and contrast it with the rough adherent mucosa of the gums, hard palate and tongue.
   - Raise the tip of the tongue and note the following features: **Lingual frenulum**, is a triangular vertical fold tethering the inferior surface of the tongue to the floor of the mouth. The **sublingual caruncle** is located on each side of the lingual frenulum and receives the opening of the duct of the submandibular gland. The **sublingual fold** passes back and laterally from the caruncle & overlies the sublingual salivary gland. The **deep lingual vein**, runs on the inferior surface of the tongue, on each side of the lingual frenulum and overlies the deep lingual artery.
   - Strongly protrude the tongue and using a tongue depressor, if necessary, observe the following features: the **sulcus terminalis**, which is a V-shaped groove on the dorsum of the tongue, **foramen caecum**, at the apex of the **V** and the **vallate papillae** (8-12 in number) located just anterior to the sulcus.
   - Examine the **hard palate**. Note the transverse palatine folds, which help the tongue to grip food. Using a torch and tongue depressor, examine the **soft palate**. Instruct the subject to say "ahhhh" and note: the **uvula**, which hangs down from the soft palate, the **palatoglossal and palatopharyngeal folds**, which descend anteriorly and posteriorly respectively from the soft palate and enclose the **tonsillar fossa**, a triangular depression between the palatoglossal and palatopharyngeal folds. The **palatine tonsil** lies vertically in this fossa (unless it has been surgically removed) and shows numerous depressions on its surface.
   - Using a torch and tongue depressor, identify the tonsil, the palatoglossal and palatopharyngeal folds (the so-called "**pillars of the fauces**").
   - Palpate the visceral tubes (pharynx, larynx, esophagus, trachea: "PLOT") during swallowing and deduce the roles of the tongue, palate and pharyngeal musculature during swallowing.

Materials: **Bones:** Articulated skeleton, skulls, loose mandible, maxilla, palatine and sphenoid bones; **Prosected specimens:** pharynx, Superficial & deep head, neck and face; wet and plastinated specimens of pharynx; deep thorax; coronal face; pharyngeal head; loose tongue; **Models:** small larynx and tongue, infratemporal fossa; **Radiographs:** X-rays– HNF, visceral; **Accessory:** pocket torches, tongue depressors,

TUTORIAL/LABORATORY CLASS 8
ABDOMINAL WALL, INGUINAL CANAL AND PERITONEUM

Aims: To describe the boundaries of the abdomen, muscles, innervation and blood supply of the abdomen. To describe the disposition of peritoneum, understand the parietal and visceral peritoneum; to describe the peritoneal fold and ligaments; to understand the peritoneal reflection and formation of pouches; to describe the innervation of the peritoneum.

Specific objectives

1. To define the boundaries of the abdominal cavity.
2. To identify general areas of attachment and orientation of muscles forming: the anterior and lateral abdominal walls (external and internal obliques, transversus and rectus abdominis muscles); the posterior abdominal wall (diaphragm, psoas major, (psoas minor) quadratus lumborum and iliacus). Identify the rectus sheath and describe its formation.
3. To describe the walls of the inguinal canal and the location of the deep and superficial inguinal rings.

4. To divide the anterior body wall into nine regions: epigastric, umbilical, hypogastric, and right and left hypochondriac, lumbar and inguinal or iliac. Identify the organs and structures as they can be topographically identified in these nine regions.
5. To describe the somatic nerve supply of the abdominal wall and relate the concept of referred pain from the underlying peritoneum.
6. To describe the disposition of the peritoneum in sagittal sections through the abdomen and in horizontal sections at the level of the hilum of the spleen and the omental foramen. Follow a tour of the peritoneal cavity in sagittal and transverse sections of the abdomen and understand the reflections of the peritoneum.
7. To identify the parietal and visceral peritoneum and the peritoneal cavity or sac. To describe the location of the greater sac and lesser sac and the omental or epiploic foramen.
8. To identify the peritoneal folds: mesentery, transverse and sigmoid mesocolons, the greater and lesser omenta (hepatogastric and hepatoduodenal ligaments), the gastrosplenic, phrenicolienal and splenorenal (or lienorenal) ligaments), the falciform and coronary ligaments, ligamentum teres and mesoappendix.
9. To state the blood and nerve supply to the visceral and parietal peritoneum, and the anterior abdominal wall.
10. To identify the folds and pouches in the peritoneal cavity of male and female and understand the reflections of the peritoneum.

Learning Activities:

1. Examine the prosections of the **posterior abdominal wall**. Identify the **psoas major**, **quadratus lumborum** and **iliacus** muscles. Remember diaphragm forms the floor of thoracic cavity and roof of the abdominal cavity. Revise the gross anatomy of **diaphragm** and its **associated apertures**.

2. Examine prosections of **anterolateral abdominal wall** and identify the **external**, and **internal oblique** and the **transversus abdominis** muscles, their attachments and direction of fibres. Identify the **rectus abdominis muscle**. Identify the **linea alba** and **linea semilunaris**. *What is the **conjoint tendon**?*

3. In the prosected specimens of the anterior abdominal wall identify the **rectus abdominis** muscle on either side of the midline/linea alba and discuss the formation of the **rectus sheath** and its walls.

4. Discuss the action and the role of the anterolateral abdominal muscles during movements of the vertebral column and phases of respiration.

5. Identify the associated **umbilical folds and ligaments**: **median** and **medial umbilical folds** and **ligaments** and vessels of the rectus sheath and the anterior abdominal wall. Identify the **lateral umbilical fold**. *What structures lie under these fold and ligaments?*

6. **Inguinal canal:** In the prosected specimens of anterior abdominal wall identify the **superficial** and **deep inguinal rings** and the **inguinal canal** between these rings. *Discuss the indirect and direct inguinal hernias*. Note that the indirect inguinal hernia is the most common form of inguinal hernia. It is a protrusion of the abdominal contents beyond the normal confines of the abdominal wall, through the inguinal canal or the anterior abdominal wall. Hernia is made of a neck and diverticulum of peritoneum forming the hernial sac. In an indirect inguinal hernia the hernial sac enters the deep inguinal ring, inguinal canal and then exits through the superficial inguinal ring. It may follow to the scrotum accompanied by the spermatic cord. The neck of indirect inguinal hernia is located lateral to the inferior epigastric vessels. Direct inguinal hernia pushes through the posterior wall of the inguinal canal, exits through the superficial inguinal ring and its neck is felt to be located medial to the inferior epigastric vessels. *Discuss the occurrence of hernias in the population. How do the indirect and direct inguinal hernia compare to the femoral hernia?*

7. In the prosected specimens of superficial and deep abdomen identify the disposition of the **peritoneum**, **peritoneal folds** and **pouches** as listed in **SO 8**. Note on the diagrams and

specimens: the disposition of the **parietal** and **visceral** peritoneum and the "**mesenteric**" folds that are associated with the abdominal organs. Discuss the peritoneal cavity and its division into **greater sac** and **lesser sac**. *Make a list of the structures and viscera that are: i) intraperitoneal, ii) retroperitoneal and, iii) subperitoneal.*

8. Discuss with your tutor and colleagues the formation of the **peritoneal folds** and **ligaments**. Note that this is best understood based on the embryological basis.
9. Describe the areas or **regions on the abdomen**: right and left **hypochondrium**; right and left **lumbar**; right and left **iliac**; **epigastrium**; **unbilical**; and **hypogastrium**. Using the torso model and the prosected specimens make a list of the organs that are found in each of these regions.
10. Describe the blood and nerve supply of the parietal peritoneum and the anterior abdominal wall.
11. **Discuss clinical problems 22, 23 and 24**.

Lecture Notes

1. **Abdomen** is the region between thorax superiorly and pelvis inferiorly. The abdomen is bound anteriorly by the following musculoskeletal structures: xiphoid process of sternum, lower six ribs and their costal cartilages; posteriorly by the lower thoracic and lumbar vertebral column; superiorly by the thoracic diaphragm; and inferiorly it is continuous with the pelvic cavity only separated from it by the reflections of the peritoneum over the pelvic viscera and structures.
2. **The Abdominal Cavity**

   The abdominal cavity may be divided into i) **the abdominal cavity proper** and ii) **the pelvic cavity (lesser pelvis)**.

   Abdomenal cavity is bound: superiorly by the diaphragm and anteriorly by the anterior abdominal wall, which consists of several layers (skin, subcutaneous tissue, muscle and fascia, extraperitoneal tissue, and parietal peritoneum). Posteriorly the abdominal cavity is bound by the lumbar vertebrae and posterior abdominal wall muscles and inferiorly by the reflection of parietal peritoneum over the pelvic viscera and structures. The boundary between abdomenal cavity and the pelvic cavity, called the **linea terminalis** is formed from medial to lateral by: sacral promontory, arcuate lines of the hipbone, pubic crests and upper border of the symphysis pubis.
3. **The Abdominal Wall and Muscles**
   Anterolateral abdominal Muscles:
   - **rectus abdominis and pyramidalis**
   - **external oblique**
   - **internal oblique**
   - **transversus abdominis**

   External oblique: This muscle attaches to the external surfaces and inferior borders of the lower 8 ribs, alternating with digitations of the serratus anterior and latissimus dorsi muscles. The muscle fibres pass anteriorly and inferiorly, becoming aponeurotic as the fibres reach the **linea semilunaris** (lateral margin of the rectus sheath; see below), finally ending as the **linea alba** after forming the anterior layer of the rectus sheath, or by inserting on the pubic symphysis, pubic crest, pubic tubercle and inguinal ligament (extending from anterior superior iliac spine to the pubic tubercle).

   Internal oblique: This muscle lies deep to the external oblique. It attaches to the lateral 2/3 of the inguinal ligament, anterior 2/3 of the intermediate line of the iliac crest, thoracolumbar fascia. Fibres ascend anteriorly to lower 3 or 4 ribs, or form an aponeurosis which splits to form both anterior and posterior layers of the rectus sheath (at least above the **linea semicircularis** or **arcuate line**, see below). This aponeurosis also terminates in the linea alba.

   Transversus abdominis: This is the innermost of the anterolateral abdominal wall muscles, lying deep to the internal oblique. It arises from the lateral 1/3 of the inguinal ligament, anterior 2/3 of the inner lip of the iliac crest, the thoracolumbar fascia and the internal aspects of the lower 6 costal cartilages. Fibres pass medially to insert onto the pubic crest and pecten

pubis, or become aponeurotic and contribute to the posterior layer of the rectus sheath (above the level of the arcuate line) by fusing with the aponeurosis of the internal oblique. Below the arcuate line the fused internal oblique and transversus abdominis aponeuroses form the anterior layer of the rectus sheath.

R**ectus abdominis**: This is a long strap like muscle, which attaches superiorly to the costal cartilages of 5th, 6th and 7th ribs and the internal surface of xiphoid process. Inferiorly it attaches to the pubic crest and tubercle. It is traversed by 3 **tendinous intersections** (at the levels: umbilicus, xiphoid apex, half-way between). Rectus abdominis and pyramidalis muscles are enclosed in the rectus sheath (see below).

The rectus sheath:

The rectus abdominis muscle is enclosed in a sheath, which is formed from the aponeuroses of the external oblique, internal oblique and transversus abdominis muscles. The pattern of contribution differs at various levels through the sheath. The traditional account of the formation of the rectus sheath is shown in the accompanying diagram.

Note the following points:

a) From the costoxiphoid margin to the arcuate line, the anterior wall of the rectus sheath consists of: external oblique aponeurosis and the anterior layer of the split internal oblique aponeurosis. The posterior wall is formed from the posterior layer of the internal oblique aponeurosis and the transversus aponeurosis. All these aponeuroses fuse at the midline to form the **linea alba**. Behind the transversus abdominis aponeurosis lies the transversalis fascia, a thin areolar stratum between the transversus and the extraperitoneal fat.

b) Below the arcuate line all three aponeuroses pass anteriorly to the rectus muscle. The aponeuroses of the transversus and internal oblique are closely fused (see conjoint tendon below) and the aponeurosis of the external oblique is either separate or loosely bound to them, except near the linea alba, where they all fuse.

Blood Supply of the Anterolateral Abdominal Wall

- Branches of the **internal thoracic A**.: **superior epigastric** and musculophrenic aa.
- Branches of the external iliac A.: **inferior epigastric** and deep circumflex aa.
- **Inferior phrenic a.** (br of abdominal aorta).
- Lower posterior intercostal and subcostal aa (from thoracic aorta).
- **Lumbar aa** (from abdominal aorta).

Nerve Supply of the Anterolateral Abdominal Wall

- Thoraco-abdominal and subcostal nerves (lower 6 or 7 thoracic segments)
- Iliohypogastric and ilioinguinal nerves (L1).

The Posterior Abdominal Wall

The muscles:

- **iliacus**
- **quadratus lumborum**
- **psoas major and minor**
- **crura of the diaphragm**

Diaphragm: revise the attachments, action and nerve supply of diaphragm (Lab 3). Revise the structures passing through various apertures in the diaphragm.

Quadratus lumborum: This muscle extends from the lower border of the 12th rib to attach medially to the apices of transverse processes of the lumbar vertebrae and inferiorly to the iliolumbar ligament and iliac crest. It is ensheathed in the anterior and posterior layers of the **thoracolumbar fascia**. The fascia overlying the upper border of this muscle is thickened as the **lateral arcuate ligament**.

Psoas major: This muscle attaches to the anterior surfaces and lower borders of the transverse processes, bodies and intervertebral discs of the lumbar vertebrae (L1-L5). The

muscle belly then descends along the pelvic brim, joins the iliacus tendon to form the **iliopsoas** tendon, passes deep to the inguinal ligament (mid-point) and inserts into the lesser trochanter of femur. Fascia overlying the upper border of psoas major muscle is thickened into as the **medial arcuate ligament**.

Iliacus: This muscle attaches proximally to iliac fossa, inner lip of the iliac crest, ventral sacroiliac and iliolumbar ligament and distally the muscle converges into the lateral aspect of the psoas major tendon to form the iliopsoas tendon to inserts into the lesser trochanter of femur.

Blood Supply of posterior abdominal wall: lumbar aa from the abdominal aorta.

Nerve Supply:

Psoas major: ventral rami of L1, 2, 3 spinal nerves.
Iliacus: brr of femoral n. (L2, 3)
Quadratus lumborum: ventral rami of T12, L1, 2, 3, 4.

4. **Surface anatomy:** Identify following important **points of reference and regions** of the abdomen:
   - The abdomen is divided into **nine regions**, by two horizontal and two sagittal planes. Some authors consider superiorly, the **subcostal plane** that passes through the lowest points of the tenth costal cartilages; and inferiorly the **intertubercular plane** that passes through the tubercles on the iliac crests about 2-thumb breadth posterior to the anterior superior spines, which are also the highest points of the iliac crests. An alternative method is by using the following lines:
   - **Horizontal planes:**

     The ***transpyloric plane*** approximately lying midway between the jugular notch and the upper border of the pubic symphysis and it passes in most cases cuts through the pylorus, the tips of the ninth costal cartilages and the lower border of the first lumbar vertebra;

     Inferiorly another transverse line that passes midway between the transpyloric plane and the upper border of the symphysis pubis is called the ***transtubercular*** plane and, it passes through the tubercles of iliac crests and this plane cuts the body of the fifth lumbar vertebra.
   - **Vertical planes:**

     Right and left lateral lines drawn vertically through points midway between the anterior superior iliac spines and the middle line.

     Some authors use ***midclavicular lines*** instead.

     By means of these horizontal and vertical planes the abdomen is divided into nine regions: **Right and left hypochondrium**; **epigastrium** just inferior to the xiphoid process; **Right and left lumbar regions** with **umbilical region** in the middle; **Right and left iliac or inguinal regions** with **hypogastrium** in the middle just superior to pubic symphysis.

     In the middle line of the front of the abdomen is a shallow furrow called the **linea alba**, which extends from the xiphisternal to the pubic symphysis.

The Inguinal Canal:

The inguinal canal is an oblique passage through the abdominal wall (3 to 5 cm in length), extending from the **deep** to the **superficial inguinal rings** along the inguinal ligament. The deep inguinal ring is in the transversalis fascia and may be found deep to the **midinguinal point** (halfway between the anterior superior iliac spine and the midline, along the inguinal ligament). The superficial inguinal ring is found 1 cm superior and 1 cm lateral to the pubic tubercle. As the inguinal canal passes through the abdominal wall it passes through each of the various layers, which make up that wall (see accompanying diagram).

The **floor** of the inguinal canal is formed by inguinal ligament and medially its attachment is called the **lacunar ligament**. The **anterior wall** is formed by the internal

oblique muscle laterally and the external oblique aponeurosis medially. The posterior wall is formed laterally by the transversalis fascia and the transversus abdominis aponeurosis, and medially by the **conjoint tendon,** which is formed by the fused aponeuroses of the internal oblique and transversus abdominis muscles. The **roof** is formed medially by the arching fibres of the internal oblique and laterally by the transversus abdominis muscle.

The inguinal canal contains the **spermatic cord** with its coverings (male) or **round ligament of the uterus** (female) and the **ilioinguinal n.** in both sexes. As the spermatic cord descends through the inguinal canal it acquires layers of fascia derived from each layer of the abdominal wall. The internal spermatic fascia is derived from the transversus abdominis and transversalis fascia, the cremasteric fascia is derived from the internal oblique layer, the external spermatic fascia is derived from the external oblique layer.

Hernia:

Note: Passage of the inguinal canal through the abdominal wall would tend to weaken the wall and allow herniation. A **hernia** is defined either as the protrusion of a viscus or a sac with internal peritoneal fluid through an abnormal body wall opening, or the abnormal protrusion of a viscus or internal fluid sac through a normal but widened opening. In a normal individual herniation through the inguinal canal is prevented by several factors:

i) Any increase in intra-abdominal pressure as caused by coughing, sneezing, straining and other similar causes, pushes the posterior wall of the inguinal canal against the anterior wall, thus closing the canal under conditions which are likely to force a viscus through it.

ii) The muscle and fascial layers of the inguinal canal are arranged in a criss-cross fashion so that contraction of the abdominal wall muscles (which would raise intra-abdominal pressure) closes the inguinal canal like a camera shutter or a collapsed bridge. Inguinal herniae are rare in women.

Indirect inguinal hernia is the most common form of hernia and may occur if the inguinal canal is abnormally patent hence called *indirect inguinal hernia* especially in young boys and infants. It is a protrusion of part of the abdominal contents beyond the normal confines of the abdominal wall. The hernial sac is a diverticulum of peritoneum and has a neck and a body. It enters the inguinal canal through the deep inguinal ring, lateral to the inferior epigastric vessels. It may extend as far as the superficial ring or down into the scrotum**.**

Direct inguinal hernia pushes directly through the posterior wall of the inguinal canal, and it is located medial to the inferior epigastric vessels. The posterior wall of the inguinal canal deep to the superficial inguinal ring becomes weak in old age or in prolonged illnesses and because the protrusion takes place directly through the anterior abdominal wall and superficial inguinal ring it is called the *direct inguinal hernia*. It is often seen in older male, overweight, patients with chronic bronchitis and/or people with long history of smoking.

The Abdominal and Peritoneal Cavity

The abdominal cavity is lined by a serous membrane called the **parietal peritoneum** and the membrane that is reflected to cover the viscera partially or completely is called the **visceral peritoneum**. The potential space that lies between the parietal and visceral peritoneum is called the **peritoneal cavity** and it normally contains the **peritoneal fluid**, which lubricates the cavity and facilitates the movement of the parts of the gastrointestinal tract during peristalsis. The parts of peritoneum, which cover the connective tissue suspending or attaching the viscera to the anterior, superior or posterior abdominal walls forms the **peritoneal folds**. The peritoneal fold is known as: **mesentery** (if attaching to or suspending small intestine), **omentum** (if attaching to or suspending the stomach) or **mesocolon** (if attaching to or suspending the large bowel). There are also visceral peritoneal folds known as **ligaments**, which are often subsets of the omenta or mesenteries, eg the **lesser omentum** connecting the stomach, duodenum and liver may

be divided into **hepatogastric** and **hepatoduodenal ligaments**. Liver has its own ligaments that attach it to the abdominal wall and these are: **falciform ligament, coronary ligament, right triangular ligament and left triangular ligament**. Inferiorly the peritoneum is reflected over the pelvic viscera and forms peritoneal folds and pouches for example in male the fold and pouch between the urinary bladder anteriorly and the rectum posteriorly is called the **rectovesical pouch and fold**. Similarly in females there are two such folds and pouches for example the fold and pouch between rectum and uterus is called the **rectouterine fold and pouch** and the fold and pouch between uterus and urinary bladder is called the **uterovesical fold and pouch**.

Many structures in the abdomen either i) develop completely outside the peritoneal sac (eg, kidneys, ureters, adrenal glands, major blood vessels, terminal 1/3 of the rectum), or ii) were once suspended in the abdominal cavity and during development become fused to the posterior abdominal wall and lose their supporting mesentery or mesocolon (eg. descending and ascending colon in most people and duodenum in all people). In all these cases these structures are said to be **retroperitoneal**.

Understand the concept of the structures that move freely in the peritoneal cavity and the others that are fixed to the abdominal wall/s. Identify the following abdominal viscera: esophagus, stomach, duodenum, jejunum, ileum, caecum, appendix, ascending colon, transverse colon, descending colon, sigmoid colon, rectum, liver, gall bladder, pancreas, spleen, kidneys, suprarenal glands.

The abdominal cavity: is divided by mesenteric folds into two sacs.

The **greater sac:** is of course, the largest and communicates with the **lesser sac (omental bursa)**, lying posterior to the stomach and lesser omentum, through the **epiploic foramen**. The epiploic foramen is bounded in front by the hepatoduodenal ligament.

The peritoneal folds and pouches:

a) Liver:

Falciform ligament: is a double-layered fold of peritoneum that extends from the liver to the anterior abdominal wall and diaphragm.

Ligamentum teres is not a peritoneal fold but is the remnant of the obliterated left umbilical vein and lies in the free edge of the falciform ligament and extends from the groove for the ligamentum teres on the visceral surface of the liver to the umbilicus.

Superior/anterior and inferior/posterior layers of the coronary ligament are the reflections of peritoneum from the superior and posterior surfaces of the liver to the diaphragm and surround/enclose the bare area of the liver. **Bare area of the liver** is where the liver is not covered by peritoneum.

Left and right triangular ligaments: The two layers of the coronary ligament meet on the left and right side and form the right and left triangular ligaments respectively. These are often easier to feel than to see.

b) Stomach:

Lesser omentum: is a double-layered fold of peritoneum that extends from the porta hepatis of liver and floor of the groove for the ligamentum venosum of the liver to the lesser curvature of the stomach and first part of the duodenum. The lesser omentum is divided into **hepatogastric** and **hepatoduodenal ligaments**.

Greater omentum: is a double-layered fold of peritoneum that extends from the greater curvature of the stomach anteriorly over most of the abdominal viscera. It fuses with the transverse mesocolon supporting the transverse colon. It has three parts:

Gastrosplenic/gastrolienal ligament: connects the lateral aspect of the fundus and greater curvature of the stomach to the spleen at its hilum.

Gastrophrenic ligament: connects the diaphragm to the posterior aspect of the fundus of stomach and the abdominal esophagus.

Gastrocolic ligament: connects the greater curvature of the stomach and first part of duodenum to the inferior border of transverse colon.

Note embryologically:

i) The liver develops in the ventral mesogastrium and the spleen in the dorsal mesogastrium.

ii) The falciform, coronary and triangular ligaments are derived from that part of the ventral mesogastrium connecting the liver to the body wall.

iii) The gastrohepatic and hepatoduodenal ligg are derived from that part of the ventral mesogastrium connecting the stomach and the liver.

iv) The gastrosplenic and gastrophrenic, as well as the lienorenal and phrenicolienal ligg are derived from the dorsal mesogastrium.

c) Intestines and Colon:

The mesentery: is a double-layered fold of peritoneum that supports the jejunum and ileum. The root of mesentery extends from the duodenojejunal flexure to the terminal part of ileum and is attached from the left of midline at LV2 to the front of Rt sacroiliac joint at the level of LV5.

Transverse mesocolon: is a double-layered fold of peritoneum that connects the superior border of the transverse colon to the anterior surface of pancreas lying on the posterior abdominal wall.

Mesoappendix: suspends the appendix and contains the appendicular vessels and nerves.

Sigmoid mesocolon: is a double-layered fold of peritoneum that supports the sigmoid colon and is attached to the posterior abdominal wall at the Lt pelvic brim anterior to the Lt ureter.

Phrenicocolic ligament: joins the left colic flexure to the diaphragm.

d) Several folds are visible on the parietal peritoneum on the internal surface of the anterior abdominal wall

Median umbilical fold: is a single fold raised by the underlying urachus or allantois (an embryological remnant), which extends from the urinary bladder to umbilicus.

Medial umbilical folds: paired folds that are raised by the obliterated umbilical arteries and extend from the internal iliac arteries to the umbilicus.

Lateral umbilical folds: are paired folds that are raised by the inferior epigastric arteries, and extend from the anterior abdominal wall just medial to the deep inguinal rings to terminate on each side of the arcuate lines of the posterior wall of rectus sheath.

e) Several pouches can be identified in the inferior part of the peritoneal cavity and these are formed by reflections of the peritoneum over the pelvic organs and structures:

Rectouterine pouch (in females): separates the rectum from the uterus and posterior fornix of the vagina.

Vesicouterine pouch (in females): separates the bladder from the uterus.

Rectovesical pouch (in males): separates the rectum from the bladder.

Blood Supply of the Peritoneum

Parietal: lumbar vessels, brr of inferior and superior epigastric aa, musculophrenic and deep circumflex aa.

Visceral: from arteries supplying the appropriate viscera.

Nerve Supply to the Peritoneum

Parietal: receives somatic nerves from the ventral rami of spinal nerves supplying the adjacent body wall and diaphragm. These are the terminal parts of intercostal nerve, iliohypogastric and ilioinguinal nerves, and the phrenic nerves.

Visceral: derived from sympathetic nerves that supply the underlying viscera.

Pain in the abdomen is caused by the sensitivity of the receptors to:

- overdistension of the hollow viscera
- traction on the mesenteries/peritoneal folds, which stretches the nerve plexus in the wall of the organ or mesentery.
- spasm of smooth muscle.
- ischaemia (inadequate blood supply).

Materials: Articulated skeleton; **Prosected specimen:** superficial and deep abdomen, anterior abdominal wall (male and female); Posterior abdominal wall specimens; Lower limb specimen that has an inguinal hernia, (if available), deep thigh, lateral pelvic wall (male and female), Celiac specimen; **Models** Torso, models lateral pelvic walls male and female.

TUTORIAL/LABORATORY CLASS 9
THE OESOPHAGUS, STOMACH AND COELIAC TRUNK

Aims: To describe the gross anatomy of esophagus and stomach; to describe the branches of the celiac trunk and their distribution.

Specific Objectives

1. To define the length and position of the esophagus.
2. To identify the esophagus in the neck, thorax and abdomen, including the major structures in immediate relationship to it.
3. To state the nerve and blood supply of the esophagus.
4. To interpret barium meal radiographs of the esophagus.
5. To state the gross subdivisions and internal features of the stomach and name its surfaces and borders, and to describe common variations in the form and position of the stomach.
6. To locate i) the posterior relations of the stomach i.e. the chief structures forming the 'stomach bed' and ii) the anterior relations of the stomach
7. To interpret radiographs of the stomach.
8. To state the nerve and blood supply of the stomach and its lymphatic drainage.
9. To describe the branches of the coeliac trunk/artery.

Learning Activities

1. Identify the **cervical**, **thoracic** and **abdominal** parts of the **esophagus**. Note the structures that lie in immediate relationship with the three parts of esophagus. Discuss the blood and nerve supply of the esophagus. *What are the component parts of the **esophageal plexus**?*

2. Discuss the arterial supply, venous drainage and lymphatic drainage of the esophagus. In the prosected specimens of the thorax, identify the **inferior thyroid vessels**. Identify the **coeliac trunk**, its branch the **left gastric artery**. Identify the **esophageal branches** of the left gastric artery. Identify the **inferior phrenic** branch of the abdominal aorta.

3. Identify and observe the form, location/position of the **stomach**. Identify the anterior and posterior relations of the stomach. *Which structures contribute to form the **stomach bed**?* Identify the peritoneal attachments of the stomach: **lesser omentum** and **greater omentum**.

4. Identify the gross anatomical structure; external; and internal features of the stomach. In prosected specimens and loose stomach specimens identify **externally cardiac** and **pyloric** parts; **greater** & **lesser curvatures**; **fundus**, **body**, **pyloric antrum** and **pyloric canal**; **cardiac incisure** and **incisura angularis**. **Internally** identify the **rugae**, **pyloric sphincter**, and **pylorus**.

5. Identify the branches of the **celiac trunk** i.e. **splenic**, **common hepatic** and the **left gastric arteries**. Examine the branches of common hepatic artery into **gastroduodenal** and the **hepatic artery proper**. The gastroduodenal artery gives of **right gastroepiploic** and **superior pancreaticoduodenal arteries**. The hepatic artery proper gives of the **right gastric artery** that supplies the lesser curvature of the stomach and then divides into **right** and **left hepatic arteries**. The splenic artery gives of the **short gastric** arteries that supply the fundus and **left gastroepiploic artery** that supplies the greater curvature of the stomach. Identify the **left gastroepiploic** branch of the gastroduodenal artery that supplies the greater curvature of stomach.

6. Identify the **portal vein**. Note the venous drainage of the stomach enters the **portal vein**. *What are the tributaries of the portal vein? Where does the portal vein begin and terminate?*
7. Describe the autonomic nerve supply of the stomach and identify the **anterior** and **posterior vagal trunks**. Identify the **coeliac ganglion and plexus** and discuss the autonomic nerves that enter and leave the coeliac plexus.
8. **Discuss clinical problems 25, 26 and 27.**

Lecture Notes

A) The esophagus

The esophagus is approximately 25 cm long and extends from the pharynx to the cardiac portion of the stomach. It begins at the level of the lower cricoid border (CV6), and passes through the diaphragm at TV10. It ends at the level of TV11 in the cardiac orifice of the stomach.

In its **course**: it begins in the midline, deviates to the left at the root of the neck, returns to the midline at TV5, deviates to the left again from TV7 to the gastric cardia. Muscle of the esophageal wall is striated in the upper 1/3, mixed striated and smooth in the middle 1/3, and smooth in the lower 1/3.

The esophagus is divided into 3 parts: **cervical**, **thoracic** and **abdominal**.

Important relations:

Part	**Anterior**	**Posterior**	**Left**	**Right**
Cervical	trachea thyr. isth. Lt Rec. Lar. n.	vertebrae long. colli	Lt inf thyr a. Lt CCA thyroid Lt subclav. a thoracic duct	Rt CCA. Rt Rec. Lar. n thyroid
Thoracic	trachea Lt main bronchus Lt atrium Lt vagus n. Lt CCA Rt Pulmonary a. Diaphragm	vertebrae Rt vagus n. thor. duct right posterior intercostal aa	Lt pleura aortic arch thoracic aorta	Rt pleura. azygos v.
Abdominal	ant. vagal trunk Lt liver lobe lesser omentum	vertebrae post. vagal tr. L crus of diaphragm	fundus of stomach spleen	aorta coeliac plexus

The oesophagus is the narrowest part of the gastrointestinal tract and has 4 major **anatomical constrictions**:

i) at its beginning (CV6), formed by the inferior constrictor of the pharynx.
ii) at the point where it is crossed by the aortic arch, TV4.
iii) at the left main bronchus, TV5, 6.
iv) where it crosses the diaphragm, TV10.

These constrictions are important to note and remember during the gastroscopy, when passing the instruments down the esophagus. These sites are also the likely sites of obstruction in the event of esophageal scarring after swallowing caustic substances.

Blood supply:

The esophagus is supplied according to the part and their direction of supply is generally longitudinal.

Cervical part: inferior thyroid br of the thyrocervical trunk.

Thoracic part: branches of the descending aorta, bronchial aa.

Abdominal part: brs of the left gastric a. and the inferior phrenic a.

Venous drainage:

Veins from the **cervical** part drain into the inferior thyroid vv.

Venous drainage from the **thoracic** part enters into the azygos, hemiazygos and accessory hemiazygos vv.

Veins from the **abdominal** part drain into the abdominal part of the azygos vein and left gastric vv. The left gastric v. is a tributary of the portal v, thus this is a site of *portal-systemic anastomosis*. In portal obstruction (eg cirrhosis of the liver) the anastomotic veins may become varicose called the **esophageal varices** and burst into the lower esophagus, causing a fatal hemorrhage and vomiting of blood called the **hematemesis**.

Lymphatic drainage:

Lymphatics from the **cervical** part drain into deep cervical;

From the **thoracic** part lymphatics drain into the posterior mediastinal.

From the **abdominal** part lymphatics drain into the left gastric nodes. The left gastric nodes drain into the coeliac nodes and then to the thoracic duct.

Nerve supply:

The **cervical** part receives rami from the recurrent laryngeal nn and postganglionic sympathetic nerves from the cervical sympathetic trunks via the plexus around the inferior thyroid a.

The **thoracic** part is innervated by: branches from the vagal trunks and the esophageal plexus, the sympathetic trunks and the greater splanchnic nn. Note that the sympathetic ganglia may be scattered through out these autonomic plexuses and some fibres from the greater splanchnic nerve may synapse in these ganglia (Lockhardt, p.337) and others travel to the coeliac ganglion and synapse there.

The **abdominal** part is supplied by the vagal trunks (anterior and posterior gastric nn), thoracic sympathetic trunks, greater and sometimes lesser splanchnic nn and the plexuses around the Lt gastric and inferior phrenic aa.

B) The Stomach

This is the most dilated part of the gastro-intestinal tract.

External features:

Stomach has two surfaces (**anterior** and **posterior**), two borders or curvatures (**greater** and **lesser curvature**), and two openings (**cardiac** and **pyloric**). It has a capacity in adult life of about 1500 ml.

Several parts are described:

i) The **cardiac part**, with the **cardiac orifice** situated to the left of the midline behind the 7th costal cartilage, 2.5 cm from its sternal junction at the level of TV11. The right crus of diaphragm surround the cardiac orifice and make the physiological sphincter. Although not a prominent sphincteric action, the normal tone of the circular muscle layer of the esophagus may maintain the orifice closed.

ii) The **fundus**, is that part of the stomach that lies above the level of the cardiac orifice and is separated from the cardiac part by the **cardiac notch or incisure**.

iii) The **body**, being the greater part of the stomach.

iv) The **lesser curvature** (right border) bearing the attachment of the lesser omentum and the **angular incisure** at its most dependent part.

iv) The **greater curvature**, gives attachment to the greater omentum and gastrosplenic ligament.

v) The **pyloric part** is made of a dilated part called the **pyloric antrum** and lies to the right of the angular incisure. The pyloric antrum becomes continuous as the narrow and thick walled **pyloric canal**, terminating at the **pyloric orifice**. The pyloric orifice is surrounded by the circular smooth muscle fibres of **pyloric sphincter**. The pyloric orifice is often marked externally by a circular **pyloric constriction** and often has a prepyloric vein crossing its anterior surface vertically. The pyloric orifice lies about 1.2 cm to the right of the midline in the transpyloric plane (LV1) when the stomach is empty and the patient supine.

Important relations:

I) **Anterosuperior surface**:

- left costal margin
- left diaphragm (6th to 9th intercostal spaces)
- gastric surface of the spleen
- left and quadrate lobes of the liver
- anterior abdominal wall
- transverse colon (when the stomach is empty)

II) **Posteroinferior surface (stomach bed):** This surface is covered by peritoneum except at the cardiac region, where the stomach is directly related to the Lt crus of the diaphragm and Lt suprarenal gland. The rest of this surface is related to the above structures across the lesser sac. Identify:

- diaphragm (Lt crus)
- Lt suprarenal gland
- upper pole of Lt kidney
- splenic A.
- anterior surface of pancreas
- Lt colic flexure
- transverse mesocolon

Stomach interior:

Muscles of the stomach lie in three intertwined layers: innermost being **oblique**, middle layer is **circular** and the outermost layer is **longitudinal**.

Longitudinal mucosal folds known as **rugae**, are seen leading from high in the body to the pyloric antrum and canal. These are also visible in barium meal films as the barium lines the grooves between the folds.

Phases of gastric secretion:

i) cephalic: secretion in response to smell and taste of food.
ii) gastric: in response to the presence of food in the stomach.
iii) intestinal: gastric secretion and motility is <u>decreased</u> by impulses from the duodenum.

Arterial supply of the stomach:

The stomach is derived from foregut and it is supplied by branches of the artery of foregut, the **coeliac artery or trunk.** See below for pattern of division of coeliac trunk.

Note the following aa**:**
i) **Lt gastric a.** (br of the coeliac trunk) supplying the lesser curvature.

ii) **Rt gastric a.** (br of the common hepatic a.) " " " .

iii) **Lt gastro-epiploic a.** (br of the splenic a.) supplying the greater curvature.

iv) **Rt gastro-epiploic a.** (br of the common hepatic a.) " " .

v) **Short gastric a. (or arteries)** from the splenic a., supplying the fundus and far left greater curvature.

vi) The pyloric sphincter is supplied by the **gastric** and **pyloric** aa (rami of the Rt gastric and gastro-epiploic aa).

Venous drainage of the Stomach:

Larger veins generally accompany main arteries.

i) **Rt gastroepiploic v.** drains into the superior mesenteric v, thence to the **portal v**.

ii) **Lt gastro-epiploic v.** drains into the splenic v, thence to the **portal v**.

iii) **Lt** and **Rt gastric veins** drain into the **portal v.** directly.

Lymphatic drainage of the stomach:

Gastric lymphatics are continuous at the pylorus with the duodenal lymphatics and at the cardia with the esophageal lymphatics.

Lymph channels largely follow the blood vessels and 4 main groups have been identified:

- **Lt gastric** group, draining in the region supplied by the Lt gastric a.
- The **pancreaticosplenic (pancreaticolienal)** group, draining the gastric fundus and body left of a vertical drawn from the esophagus.
- **Rt gastroepiploic** group, draining the greater curvature as far as the pylorus. These nodes drain in turn to the pyloric nodes.
- **Rt gastric** and **pyloric** nodes, draining the pyloric part of the stomach.

Efferent lymphatic from all these nodes eventually drain into the **coeliac nodes** and thence to the **thoracic duct**.

Nerve supply of the stomach:

The **celiac ganglion and celiac plexus** surround the celiac trunk. Discuss the composition of the celiac plexus.

Coeliac plexus receives: sympathetic supply from **greater** and **lesser splanchnic nn**; sensory from Lt phrenic n; and parasympathetic from **posterior vagal trunk** (see below) and is distributed through extensions of the coeliac plexus along the gastric and gastroepiploic aa.

Sympathetic nerve supply: **Greater splanchnic nerve** carrying myelinated preganglionic efferent and visceral afferent fibres. Formed from branches of T5 to T9/10 ganglia. Supplies thoracic aorta, perforates the ipsilateral crus of the diaphragm to supply mainly **coeliac** but also **aorticorenal ganglia** and also end in the suprarenal gland. Occasionally a splanchnic ganglion exists on the nerve opposite TV11/12.

Parasympathetic supply from the vagus nn: The **anterior vagal trunk** has contribution from both vagus nerves but mainly the *Lt vagus* and the **posterior vagal trunk** similarly receives contributions from both vagus nerves but mainly from the *Rt vagus*. The anterior vagal trunk gives rise to **gastric** brr (to the anterior body and fundus), **hepatic** brr and **pyloric** brr (generally 2, to the pylorus). The posterior vagal trunk gives rise to **gastric** brr (for the posterior surface of the stomach, but not the pylorus), and **coeliac** brr (to the coeliac plexus around the coeliac trunk).

C) The Coeliac Trunk

The coeliac trunk is only about 1.25 cm long and divides into **three** main branches. It may also give off the inferior phrenic aa.

Lt gastric a.
common hepatic a.
splenic a.

1) The **left gastric a.**: Ascends to the left, travels in relation to the lesser curvature of the stomach, within lesser omentum, gives off 2 or 3 esophageal brr and supplies both anterior and posterior surfaces of the stomach. It terminates by anastomosing with the right gastric artery.

2) The **common hepatic a.**: Is accompanied by the hepatic plexus and gives off the **gastroduodenal** artery after which it is called the **hepatic artery proper**.

The **hepatic a. proper** gives off **right gastric artery** and then divides into **Lt and Rt hepatic aa**. The right hepatic artery gives off the **cystic a.** to supply the gall bladder. **Rt gastric a.** travels medially and reaches to the lesser curvature of the stomach, anastomoses with left gastric artery and supplies the stomach, pylorus and first part of duodenum.

The **gastroduodenal a.**, descends vertically and gives off the **Rt gastroepiploic A.** and **superior pancreaticoduodenal a**. The latter divides into anterior and posterior brs, supplying the duodenum and pancreas as far as the greater duodenal papilla (which marks the boundary between fore- and midgut).

3) The **splenic a.** is the largest br of the coeliac trunk and ascends to the left along the superior border of the pancreas. It has several brs:

- pancreatic brr.
- **short gastric aa** (5 to 7 in number), supplying the gastric fundus and far left greater curvature.
- posterior gastric a. described by some authors as arising from the splenic a. at its middle section (present in 58% of cadavers). It ascends towards the fundus supplying the posterior gastric wall.
- **Lt gastroepiploic a.**, supplying the greater curvature and left part of greater omentum.
- **terminal splenic brr.**

Radiography: With colleagues: (a) examine **barium swallow** radiographs of the esophagus and compare them with dissected specimens and (b) identify all structures seen in immediate contact with the esophagus.

Materials: Articulated skeleton, **Models:** Torso Models, **Prosected specimens**: superficial and deep thorax; superficial and deep abdomen; coeliac specimen; loose stomach specimens. **X-Rays:** Barium meal and barium swallow radiographs,

TUTORIAL/LABORATORY CLASS 11
THE DUODENUM, PANCREAS AND SPLEEN

Aims: To describe the gross anatomy: the position, gross features, blood and nerve supply, lymphatic drainage of: the duodenum, and the viscera in immediate relationship with the duodenum, including the pancreas and spleen

Specific Objectives

1. To identify the position and gross features of duodenum, and the viscera in immediate relationship with the duodenum.
2. To name the borders, surfaces and subdivisions of the pancreas, and describe its peritoneal relationships.
3. To describe the duct system of the pancreas.
4. To list the major immediate visceral relationships of the head, body and tail of the pancreas, and its blood supply.
5. To describe the gross anatomical features, relationships, peritoneal folds and blood supply of the spleen.

Learning Activities

1. Identify the **duodenum**, its position, and its parts. Identify the **first or superior part**; **second or descending part**; **third or horizontal part** and **fourth or ascending part**. Identify the peritoneal relationships of each of these parts of duodenum.
2. Identify the **plicae circularis** in the interior of the duodenum. Identify the second part of the duodenum with **greater** and **lesser duodenal papillae**.

3. Identify the branches of the **celiac trunk** and **superior mesenteric artery** that supply the arterial blood to the duodenum.
4. Discuss the lymphatic drainage of the duodenum.
5. Identify the **pancreas** in the prosected specimens of the deep abdomen, coeliac specimens and isolated specimens of the duodenum, pancreas and spleen. With colleagues identify the parts of pancreas, its immediate peritoneal and visceral relationships of the **head**, **uncinate process**, **neck**, **body** and **tail of the pancreas**. Estimate the vertebral levels of the pancreas.
6. Identify the main **arterial supply** of the pancreas.
7. Discuss the **lymphatic drainage** of the pancreas.
8. Identify the **spleen**, its gross anatomical features, relationship to the adjacent viscera and other structures and its peritoneal attachments.
9. Identify the **portal vein** formed by the junction of the superior mesenteric and splenic veins behind the neck of the pancreas.
10. **Discuss the clinical problems 26, 27 and 28**.

Lecture Notes

1. The **duodenum** extends from the pylorus to the duodenojejunal junction. Duodenum is 25 to 30 cm long and except for the 1st part does not possess a mesentery. It is arranged in a C-shaped fashion around the pancreas. It is divided into 4 parts: **1st or superior part**; **2nd or descending part**; **third or horizontal part**; and **4th or ascending par**t.

   The **1st part of duodenum** is related:
   - *anteriorly* to liver and gall bladder;
   - *posteriorly* to portal vein, gastroduodenal artery, bile duct, lesser sac and the IVC;
   - *superiorly* to the caudate lobe of liver, hepatic artery and neck of gall bladder; and
   - *inferiorly* to the head of pancreas and gastroduodenal artery.

   The **2nd part of duodenum** is related:
   - *anteriorly* to liver, gall bladder, transverse colon and small intestine (coils of ileum);
   - *posteriorly* to right renal vessels, right kidney, IVC, psoas major muscle and right ureter;
   - *medially* to the head of pancreas and branches of pancreaticoduodenal artery and;
   - *laterally* to ascending colon and right colic flexure.

   The **3rd part of duodenum** is related:
   - *anteriorly* to the superior mesenteric vessels (SMA lies to the left of SMV) and the root of mesentery;
   - *posteriorly* to the right and left psoas major muscles, IVC, Aorta, inferior mesenteric vessels and right gonadal artery.

   The **4th part of duodenum** is related:
   - *anteriorly* to the root of mesentery;
   - *posteriorly* to the aorta and left psoas major muscle.

   Relations of the duodenum are summarised in the table below:

Part	Anterior	Posterior	Superior	Inferior
1	liver gall blad.	portal V. gastroduod. a. bile duct lesser sac IVC	liver (quadrate) hepatic a. neck of gall blad.	head of pancreas bifurcation of gastroduodenal a.

	Anterior	Posterior	Medial	Lateral
2	liver gall blad. transv. col. small int.	Rt renal vessels Rt kidney IVC psoas major Rt ureter	head of pancreas brr of sup. pancreatico-duodenal a.	ascending colon Rt colic flexure
	Anterior	**Posterior**	**Superior**	**Inferior**
3	SM vx. root of mesentery	Rt & Lt psoas Rt ureter IVC aorta inf. mesenteric a. Rt test./ovar. vessels	Hd pancreas	inf. pancreatico-duodenal a.
	Anterior	**Posterior**		
4	root of mesentery	Lt psoas major aorta		

Ligament of Treitz: also called the suspensory ligament of duodenum is a fibromuscular band that supports the duodenojejunal flexure and keeps it at an angulation so that the contents of duodenum are released slowly into jejunum. It extends from the right crus of diaphragm, to the right of esophagus, descending deep to the pancreas and reaches the junction of fourth part of duodenum with jejunum. It contains some smooth and skeletal muscle fibres and some elastic fibres.

Duodenal Fossae: There are some blind pockets of peritoneal cavity that arise during development usually at the transition zones or during the rotation of gut. These are best seen in fetuses but may persist in adults and are sites for herniation, strangulation and obstruction. **Superior duodenal fossa:** is approximately 2cm deep, found in 50% of population, is situated at the level of LV2 and opens inferiorly. **Inferior duodenal fossa:** is approximately 3cm deep, found in 75% of population, is situated at the level of LV3 and opens superiorly. **Retroduodenal fossa:** is approximately 8-10 cm deep, occasionally found, lies behind the 4th part of duodenum with its opening looking to the left.

Paraduodenal fossae/recesses: is a blind recess that is present in 20% of population, its free edge faces to the right and contains the inferior mesenteric vein in its free edge.

Internal structure of duodenum: The mucosa in the **interior of the duodenum,** except for the first part, is thrown into circumferentially arranged folds known as **plicae circulares**, which serve to increase the surface area to improve absorption. Two papillae may be seen in the medial wall of the 2nd part of duodenum. The **greater duodenal papilla** lies 8 to 10 cm from the pylorus, and at its summit has the opening of the **hepatopancreatic ampulla** (of Vater). The ampulla receives the openings of **bile duct** (guarded by **choledochal sphincter**) and the **main pancreatic duct** (guarded by **sphincter of pancreatic duct)**. The opening of hepatopancreatic ampulla is guarded by sphincter of hepatopancreatic ampulla also called **sphincter of Oddi**. The **lesser duodenal papilla** lies about 6 to 8 cm distal to the pylorus and has at its summit the opening of the accessory pancreatic duct.

Blood supply and venous drainage of the duodenum:

The duodenum is supplied from the branches of coeliac and superior mesenteric a. anastomose with each other around the level of major duodenal papilla (*the approximate site of the fore/midgut junction*).

- Rt gastric, supraduodenal, Rt gastroepiploic and superior pancreaticoduodenal aa.
- Inferior pancreaticoduodenal a. (br of the superior mesenteric a.).

Venous drainage is by the **splenic** and **superior mesenteric veins** and then into the **portal** v.

Nerve supply is from the **coeliac plexus**.

Lymphatic drainage is to the **pancreaticoduodenal nodes**.

2. **The pancreas:** The pancreas is a retroperitoneal structure about 12 to 15 cm long, which extends transversely across the posterior abdominal wall from the duodenum to the spleen. It lies mainly in the epigastrium and left hypochondrium.

   The pancreas possesses: a **head**, **neck**, **body** and **tail**. Projecting from the lower left part of the head is the **uncinate process**, which lies posterior to the superior mesenteric vessels. Identify the

   Relationships of the pancreas: The pancreas is related:

   - *Anteriorly* from right to left: to transverse colon, with its attachment of transverse mesocolon, the lesser sac and the stomach.
   - *Posteriorly* from right to left: the bile duct, the portal and superior mesenteric vv., the IVC, the aorta, the origin of superior mesenteric artery, the left psoas major muscle, the left suprarenal gland, the left kidney and the hilum of spleen.
   - Note that the **head** fits snugly into the C of the duodenum and is related *anteriorly* to transverse colon and small intestine; *posteriorly* to IVC, aorta and right crus of the diaphragm; *medially* to the second part of duodenum; superiorly to the first part of duodenum; and *inferiorly* to the third part of duodenum.
   - The **neck** is related *anteriorly* to the pylorus and lesser sac; *posteriorly* to the tributaries of the portal vein (superior mesenteric vein and splenic vein); and *superiorly* related to the splenic artery.
   - The **body** of pancreas is prismatic in shape and is described as having **anterior, posterior** and **inferior surfaces**; and **superior, anterior** and **inferior borders**. An **omental tuberosity** usually projects from the right end of the superior edge of the body and is in contact with the posterior surface of the lesser omentum.
   - The **tail** is related to the spleen and splenic vessels, and lies between the two layers of the **lienorenal (splenorenal) ligament**.

   Pancreatic ducts:

   The pancreas has two large ducts that could not be identified in the specimens. These are:

   i. the **main pancreatic duct**, which drains into the **greater duodenal papilla**,

   ii. the **accessory pancreatic duct**, which drains into the **lesser duodenal papilla**.

   Blood supply of the pancreas:

   The pancreas receives blood from the coeliac trunk via the **pancreatic** brr of the **splenic** a. and **anterior** and **posterior** brr of the **superior pancreaticoduodenal a**. In addition pancreas is also supplied by the **anterior** and **posterior** brr of the **inferior pancreaticoduodenal** a. from the **superior mesenteric a**.

   Venous drainage:

   The pancreas drains into the splenic & superior mesenteric vv and ultimately into portal vein.

   Nerve supply:

   The pancreas is supplied from the branches of coeliac plexus and ganglion along the arterial supply. **Coeliac plexus and ganglion** surround the coeliac trunk from the abdominal. It receives the preganglionic sympathetic fibres from T5-T9 levels of the spinal cord via the greater splanchnic nerve. These fibres synapse in the ganglion and postganglionic fibres form part of the coeliac plexus. The coeliac plexus also receives postganglionic parasympathetic fibres from both **vagus** nerves via the **coeliac branch** from the **posterior vagal trunk**.

Functions of pancreas:

The two **functional elements** of the pancreas include: **endocrine** and **exocrine** components.

The endocrine part is the islets of Langerhans. There are about a million islets in the human pancreas and they are usually more numerous in the tail. These secrete glucagon and insulin. A third type of cell has been identified in human pancreas and contains gastrin plus somatostatin or a similar peptide.

The exocrine part is involved in the secretion of pancreatic hormones for the digestion of food in the small intestine. Some of the enzymes secreted are trypsin, lipase and amylase. The exocrine part consists of branched acinar glands.

3. **The spleen:**

The **spleen** is the largest aggregate of lymphoid tissue in the body, situated in the left hypochondrium of the abdomen between the fundus of the stomach and the diaphragm, undercover of ribs 9, 10 and 11, with its long axis extending along the 10^{th} rib.

It has two poles or ends: the **superior or the upper pole** that lies closer to the midline and **inferior or lower pole** that lies in the midaxillary line, is overlapped by the ribs, and thus can not normally be palpated.

It has an **anterior** notched **border** and a **posterior** broad **border**.

It has two surfaces: **diaphragmatic** and **visceral surfaces**. The diaphragmatic surface is convex and smooth and is related to the abdominal surface of the diaphragm. The visceral surface has 4 impressions: **gastric, renal, colic** and **pancreatic** (tail in lienorenal ligament at the hilum). The spleen is connected to the posterior abdominal wall by the **lienorenal ligament** and to the stomach by the **gastrosplenic ligament**. The spleen is related posteriorly to diaphragm, left costodiaphragmatic recess, left lung and left 9^{th}, 10^{th} and 11^{th} ribs.

Blood supply:

The spleen is supplied by long, tortuous **splenic** artery (branch of the **celiac trunk**), which then divides into many branches. The branches that enter the spleen are end arteries.

Venous drainage:

The **splenic vein** leaves the hilum of spleen in the lienorenal ligament of the spleen, runs posterior to the tail and body of the pancreas, and deep to the neck of pancreas joins with the **superior mesenteric vein** to form the **portal vein**. The splenic vein receives the **inferior mesenteric vein** as a tributary.

Materials: Articulated skeleton; **Models** Torso; **Prosected specimens**: superficial and deep abdomen, celiac axis specimen, isolated duodenum, pancreas, and spleen; **X-Rays**: visceral radiographs.

TUTORIAL/LABORATORY CLASS 12
THE SMALL AND LARGE INTESTINE AND MESENTERIC VESSELS

Aims: The structure, position, distinguishing features and peritoneal relationship of the small and large intestine, and their blood and nerve supply, and lymphatic drainage

Specific Objectives

1. To know the divisions of the small intestine into duodenum, jejunum and ileum and revise the position and gross features of the duodenum, and the viscera in immediate relationship with the duodenum.
2. To describe the disposition of the jejunum and ileum in the abdominal and pelvic cavities.
3. To distinguish large from small intestine on the basis of macrostructural features.
4. To identify and name the subdivisions of the large intestine, and their peritoneal relationships.
5. To identify internal features of the caecum, rectum and anal canal, and the anal sphincters.
6. To identify visceral relations of the rectum and anal canal in both sexes.

7. To identify superior and inferior mesenteric arteries and their main branches. To identify the venous and lymphatic drainage of small and large intestine. To know the nerve supply of the small and large intestine.
8. To describe the mechanism of defecation.
9. To identify the jejunum and ileum in barium meal radiographs.

Learning activities

1. Examine the prosected specimens of superficial abdomen and identify three parts of small intestine: **duodenum**, **jejunum** and **ileum**. Duodenum has been described in the previous class. Identify the location and distinguishing features of ileum and jejunum.
2. Identify the **root of mesentery**, its attachment and contents. Observe demonstration of the visceral relationship of the **small intestine**.
3. Identify the disposition of the "picture" of **jejunum** and **ileum** within the framework of the large intestine.
4. Identify and name the subdivisions of the **large intestine**, their extent, peritoneal relationships, and internal and external features of **caecum**, **ascending colon**, **transverse colon**, **descending colon**, **sigmoid colon**, **rectum** and **anal canal**. On the basis of location, gross structure, and the **peritoneal** attachments, list the features that distinguish: the parts of small intestine; and the small and large intestine.
5. Identify the parts of large intestine that are retroperitoneal. Identify the **transverse** and **sigmoid mesocolons**.
6. On the basis of structure and peritoneal attachments, list features, which distinguish (a) small intestine from colon; (b) transverse colon from sigmoid colon; (c) colon from appendix.
7. Identify the **appendix** and (its mesentery) the **mesoappendix**.
8. Examine the prosected specimens and the models of the male and female pelvis and identify the disposition and relationship of the **rectum** and **anal canal**. Identify the internal features of the rectum and anal canal in the models and the prosected specimens.
9. Identify the internal anal sphincter and parts of the external anal sphincter.
10. Identify the **superior** and **inferior mesenteric arteries** and their branches supplying the small and large intestines. Identify the **jejunal**, **ileal**, **ileocolic**, **appendicular**, **right colic**, **middle colic** branches of the superior mesenteric artery. The inferior mesenteric artery gives off the **left colic**, **2 to 3 sigmoidal** and **superior rectal** arteries.
11. Identify the **internal pudendal** and **middle rectal** branches of the **internal iliac** artery, if visible.
12. Identify the **portal vein** and its **tributaries**.
13. Examine the specimens of the deep abdomen and identify the **autonomic plexuses** related with the aorta that provide the autonomic supply to the small and large intestines.
14. Discuss the **lymphatic drainage** of the small and large intestine.
15. Examine the **angiograms** and identify as many branches of the **superior mesenteric artery** as listed in LA 8.
16. Examine the **barium meal** and **barium enema** and identify the characteristic features of duodenum, jejunum, ileum, colon and rectum.
17. Identify features of the large intestine visible in plain radiographs of the abdomen and in barium meal radiographs.
18. **Discuss clinical problems 28, 29, 30, 31.**

Lecture Notes

1. **The Small Intestine**: This consists of the duodenum, jejunum and ileum.

   The **duodenum** has been described in the previous class. **Jejunum** and **Ileum**: Jejunum is approximately 2.4 meters long and begins at the duodenojejunal flexure. The ileum is 3.6 meters long and terminates at the ileocaecal junction. Together the ileum and jejunum contribute to about 5 to 8 meters in length. In the cadaver due to loss of muscle tone the length of small intestine is longer than in living.

   Wall of Intestine: From external to internal they are: i) visceral peritoneum (serous layer), ii) muscular layer: longitudinal and circular layers of smooth muscle, iii) submucous layer

composed of loose connective tissue, blood vessels and lymphatics, iv) muscularis mucosa layer composed of smooth muscle, and v) mucosa with vill composed of highly vascularised processes. In general the **jejunum** (= empty) has more folds of the mucosa called the **plicae circulares** or valves of Kerkring, more villi and a thicker, more vascular wall than the ileum. Jejunum because of these internal features is very efficient and quick in digestion, absorption and movement of food through its lumen.

Differentiating features of Jejunum and Ileum: During surgery it is very important to localise the parts of small intestine and thus it is important to note the differentiating features between the jejunum and ileum. Discuss the important distinguishing features between ileum and jejunum under the following headings:

	Jejunum	**Ileum**
position	upper and left abdomen	lower and right abdomen
extent	2/5	3/5
external feel	thick, wide, vascular	thin, narrow, pale
& appearance	redder	
Peyer's patches	few	many
(aggreg. lymph		
follicles)		
vascular arcades	few	many
vasa recti	long	short
mesenteric fat	less	more
X-Ray	feathery	uniform contour
appearance		

Peritoneal attachments: The jejunum and ileum are completely covered by visceral peritoneum and are attached to the posterior abdominal wall by the **mesentery**. Note the attachments (root) and contents of mesentery. The mesentery is a 15 cm long double-layered peritoneal fold that is pleated and fan-shaped. It has an attached border called the **root** and a free border approximately 6-7 meters long and contains the jejunum and ileum. The root of mesentery attaches to the posterior abdominal wall along an oblique line proximally extending from the duodenojejunal flexure at the level of LV2 to the left of the midline and distally to the Rt sacroiliac joint to the right of midline. Thus it passes over the horizontal or the third part of the duodenum, aorta, IVC, Rt ureter, Rt psoas major muscle, genitofemoral nerve and right ureter. **Contents of mesentery**: include the jejunal and ileal arteries, veins, lymphatics and autonomic nerves embedded within fat.

Blood supply and venous and lymphatic drainage:

Arterial supply: By jejunal and ileal branches of the **superior mesenteric a.**, which originate from its left as it descends within the two layers of the mesentery.

Venous drainage accompanies the arteries to drain into **superior mesenteric v**., which joins the **splenic v.** to form the **portal v.**

Lymphatic drainage: Lymph vessels (lacteals) are arranged at two levels: mucosal and muscular. These ultimately drain to lymph nodes of **the mesentery** and thence to the thoracic duct.

Nerve supply: Superior mesenteric plexus extends as a fine network along the branches of the superior mesenteric artery. The plexus receives *Sympathetic* supply from the **greater splanchnic** and **lesser splanchnic nn**. and *Parasympathetic* supply is received from coeliac branch of **posterior vagal trunk** and via continuation of the **coeliac plexus**.

2. **Large Intestine** is 1.5 m long in the adult and extends from the terminal ileum to the anus. Large intestine has many parts viz. **caecum**, **appendix**, **ascending colon**, **right colic flexure**, **transverse colon**, **left colic flexure**, **descending colon**, **sigmoid colon**, **rectum**, and **anal canal**. Its diameter is greatest near the caecum, gradually diminishing towards the rectum where it enlarges again just above the anal canal. Main function of large intestine is to absorb fluid and minerals, and form the stools. **Distinguishing features between small and large intestine**: Large intestine can be distinguished from the small intestine on the following points:

    - large intestine has a greater caliber.
    - large intestine is generally fixed (except for transverse and sigmoid colon).
    - longitudinal muscle in the large intestine instead of being a continuous sheet is arranged in three bands called **taeniae coli**. The length of teniae is smaller than the length of large intestine.
    - wall of large intestine is puckered into sacculations that are formed due to the presence of taeniae colii and they are called **haustrations**.
    - large intestine has **appendices epiploicae**, fat filled projections, scattered over the free surface of the colon, but absent from the caecum, appendix and rectum.

Features of individual parts of large intestine:

i) The **caecum** lies in the Rt iliac fossa and receives the terminal ileum. Internally, it shows on the medial wall, an **ileocaecal orifice**, 'protected' by a so-called valve, which consists of **superior and inferior valve leaflets**. These valves come together anteriorly and posteriorly to form **frenula of the valve**. However, radiological evidence contradicts the existence of a true functional valve at this point. The **appendicular orifice** may be identified on the medial wall, 2 cm below the ileocaecal orifice.

ii) The **vermiform appendix** arises from the posteromedial wall of the caecum. It may lie in several positions: behind the caecum or **retrocaecal** or **retrocolic** (65%), dependent over the pelvic brim or **pelvic** (31%), below the caecum or **subcaecal** (2.3%), anterior to the terminal ileum (rare) and behind the terminal ileum (rare). The usual surface marking for the appendix is **McBurney's point** (lower trisection of the line between the umbilicus and the anterior superior iliac spine), but this is only an approximation. The taenia coli of the caecum converge on the attachment of the appendix to the caecal wall. The wall of the appendix has the taeniae forming a complete longitudinal smooth muscle coat. The appendix is attached to the lower part of the ileal mesentery by the **mesoappendix**. The appendix receives blood from **appendicular** a., which is a branch of the **ileocolic** a.

iii) The **ascending colon** is about 15 cm long and is said to begin at the ileocaecal valve. It ascends to the Rt colic or **hepatic flexure**. It is retroperitoneal in most people but 25% of population may have *ascending mesocolon*. It is related posteriorly to: Rt kidney, iliacus muscle, quadratus lumborum muscle, iliohypogastric n., ilioinguinal n., and lateral femoral cutaneous n.

iv) The **transverse colon** is about 50 cm long, extending from the Rt colic to the **Lt colic** or **splenic flexure**. The transverse colon descends to the lower umbilical or upper hypogastric area and has posterior relations: duodenum, pancreas, spleen and both kidneys. The left colic flexure is attached to the diaphragm by the phrenicocolic ligament. Transverse colon is freely mobile due to attachments of: **gastrocolic ligament** (greater omentum) to its inferior border and **transverse mesocolon** to its superior border. On the anterior surface of transverse colon only one free taenia is visible called the **taenia libera**, and the other two being in the fat enclosed in the greater omentum (taenia omentalis) and transverse mesocolon (taenia mesocolica), respectively. It is attached to the posterior abdominal wall by the **transverse mesocolon**. The superior and inferior

layers of transverse mesocolon separate as they reach the posterior abdominal wall and are reflect over the retroperitoneal structures such as: (from right to the left, lower pole of the right kidney, across the 2nd part of the duodenum, pancreas, and hilum of left kidney.

v) The **descending colon** is about 25 cm long, descends from the left colic flexure to the pelvic inlet. Posterior relations of descending colon are: Lt kidney, transversus abdominis muscle, quadratus lumborum muscle, iliacus muscle and several nerves viz. ilioinguinal, iliohypogastric and lateral femoral cutaneous.

vi) The **sigmoid colon** is about 40 cm long and extending from the pelvic inlet to the mid piece of the sacrum. It usually lies in the lesser or minor pelvis. It is attached to the posterior pelvic and abdominal wall by the **sigmoid mesocolon**. Some racial groups (eg Ethiopians) possess a suprapelvic loop, which makes them prone to volvulus (twisting) of the sigmoid colon.

vii) The **rectum** is a total of 12 cm in length, continuous proximally with the sigmoid colon at the mid piece of the sacrum (S3 vertebra) and becomes continuous as the anal canal at the level of tip of coccyx. Rectum (= straight) is in fact not a straight tube and possesses several curves called the **flexures**. It descends along the sacro-coccygeal concavity as the **sacral flexure**, eventually joining the anal canal at the **anorectal junction**, 2 to 3 cm in front of the coccygeal tip. The bend at this point is known as the **perineal flexure of the rectum**. The rectum is covered by peritoneum on its anterior surface and sides in the upper 1/3, on its anterior surface only in its middle 1/3 and is not covered by peritoneum at all in its lower 1/3. The lower part of the rectum is dilated as the **rectal ampulla**. The upper part of rectum has three sharp curves: uppermost and the lowermost curves are convex to the right and in between the middle curve is convex to the left. Rectum also has three internal folds related with these curves. These are called the **transverse rectal folds**: upper and lower on the left, the middle on the right). In life the upper part of the rectum above the middle fold may contain faeces, but the lower part only contains faeces in chronic constipation or during the call to defecate. Experimental distension of the rectum and anal canal results in the desire to defecate and causes the relaxation of the anal sphincters.

Peritoneal reflections of the rectum:

Upper 1/3rd of rectum is covered by peritoneum on the anterior and right & and left sides; the middle 1/3rd is only covered anteriorly and lower 1/3rd is covered by the reflection of peritoneum to the viscera and related structures that lie anterior to rectum. This fold of peritoneum in male is reflected over the urinary bladder and is called **rectovesical** fold and in female over the uterus and is called the **rectouterine fold**.

Relationships of rectum: The rectum has several important relations: identify, anterior, posterior and lateral relationships of the rectum in male and female individuals.

	Anterior	**Posterior**	**Laterally**
Males	base of bladder seminal vesicles rectovesical pouch ileum sigmoid colon ductus deferens terminal ureter prostate	SV3, 4, 5 coccyx median sacr. vx ganglion impar sup. rectal vx	sigmoid colon ileum pelvic plexuses coccygeus m. levator ani m.
Females	uterus vagina rectouterine pouch ileum sigmoid colon	as for male	as for male

viii) The **anal canal** is about 4 cm long in adults. Posterior to anal canal lies the **anococcygeal ligament**, separating it from the tip of the coccyx. Anteriorly it is separated from the lower vagina or membranous urethra and bulb of penis by the **perineal body**. Laterally it is related to the **ischiorectal fossa**, (a space that is described in the notes of lab class or Pelvis and perineum). The upper half of the anal canal is lined by mucosa (simple columnar), which is plum red due to the internal rectal venous plexus. The lower half is lined by stratified squamous non-keratinizing epithelium. In this lower part there are 6 to 10 **anal columns**, which are vertical folds. Each column contains a terminal branch of the superior rectal artery and vein, these being largest at the 4 (3/4)pm, 7pm and 11pm positions (*4711, the house of Eau de Cologne as some surgeons would put it)* as the supine patient is viewed from the foot of the bed. Enlargements of the terminal parts of the venous channels and their anastomoses with each other gives rise to **internal hemorrhoids**.

The lower ends of the anal columns are joined together by folds of mucus membrane called the **anal valves**, above each of which is a space called the **anal sinus**. The anal valves together are known as the **pectinate line**, which is situated opposite the **internal anal sphincter** (see below). Tears of the anal valves give rise to anal fissures.

The anal canal extends below the pectinate line as the **pecten** or transitional part, which is said to be bluish in color. The pecten ends inferiorly at the **'white line'** of **Hilton**, which is actually bluish pink and is rarely visible in the living.

Anal sphincters

i) **Internal anal sphincter** (smooth muscle fibres) is formed by the involuntary circular muscle fibres and surrounds the anorectal junction and upper 2/3rd of the anal canal. It is a thickening of the circular muscle coat of rectum (5 to 8 mm). It ends at the white line. It is under the control of parasympathetics from S2, S3, S4 segments of the spinal cord.

ii) **External anal sphincter** (striated muscle fibres) is formed by ring of skeletal/voluntary muscle fibres that surround the entire length of anal canal. External anal sphincter or the sphincter ani externus consists of **three** parts from inferior to superior: **subcutaneous**, **superficial** and **deep**. The subcutaneous part surrounds the lowest part of anal canal, lies immediately deep and is attached to skin. It lies below the level of internal anal sphincter and has fibres running in circular fashion. The superficial part is oblong shaped and is attached anteriorly to the **perineal body** and posteriorly to the **anococcygeal raphe**. It lies at the level of middle part of anal canal and surrounds the internal anal sphincter. The deep part has fibres that run circular in fashion and blends superiorly with the inferior fibres of **levator ani** muscle. It encircles the upper part of the anal canal and also surrounds the internal anal sphincter.

iii) At the anorectal junction the **pubococcygeal** fibres of **levator ani** fuse with the longitudinal smooth muscle coat of the rectum to form a *conjoint longitudinal coat* for the anal canal, which lies between the internal and external anal sphincters.

iv) The muscle fibres of **puborectalis** fibres of **levator ani** form the *anorectal sling* and maintain the angulation at the anorectal junction and thus are a part of the voluntary control in holding the passage of stools.

3. **The process of defecation**. Faecal continence depends on two factors:

i) that the sigmoid colon retains faeces until defecation, dilating as it accumulates, and

ii) sphincteric control, namely the contraction of the puborectalis part of the pelvic diaphragm and the anal sphincters. Note that the anal sphincters are not capable of holding faeces in the rectum indefinitely, as they tire quickly. Consequently it is very important that faeces remain in the sigmoid until defecation is appropriate.

Defecation occurs in the following sequence:

- Faeces is held at the rectosigmoid junction until the beginning of the process of defecation.
- Faeces moves from rectum into the rectal ampulla, which normally is empty.
- Puborectalis and anal sphincters (voluntary control) relax. Puborectalis relaxation allows the anorectal junction to straighten.
- Abdominal wall musculature and rectal musculature contract, thus increasing intraabdominal and intrarectal pressure respectively and evacuating the rectum.
- During evacuation the sigmoid and descending colon move downward.
- Puborectalis and external anal sphincter contract to close the anal canal.
- The internal anal sphincter completes the closure after the passage of each faecal mass.

4. **The Blood Supply of the Small and Large Intestine**

Arterial supply:

The **superior** and **inferior mesenteric aa,** single midline anterior branches from the abdominal aorta supply the parts of small and large intestine. See the accompanying diagrams.

Branches of superior and inferior mesenteric artery:

a) Superior mesenteric a.: The superior mesenteric a. supplies the duodenum (from the greater duodenal papilla), jejunum, ileum, caecum, appendix, ascending colon and the transverse colon as far as the left trisection. Its branches include: inferior pancreaticoduodenal (ant. and post. brs), **jejunal brs**, **ileal brs**, **ileocolic** artery giving off the appendicular a., **right colic** (supplying ascending colon), and **middle colic** (supplying transverse colon).

b) Inferior mesenteric a.: The inferior mesenteric a. supplies the left 1/3 of the transverse colon, descending colon, sigmoid colon, rectum and anus as far as the pectinate line. Its branches include: **left colic** (supplying transverse and descending colon), **sigmoidal brr.** (2 to 3) and **superior rectal** (continuation of inferior mesenteric a.).

Venous Drainage of the Small and Large Intestine

Inferior mesenteric v. drains into the splenic v.

Superior mesenteric v. joins the **splenic** v. to form the **portal** v., which travels in the free edge of the lesser omentum posterior to the bile duct and hepatic a. proper to drain into the liver.

Lymphatic drainage of small and large intestine:

The lymph drainage of the small and large intestine is via mainly the **thoracic duct**.

Small intestine: the lymphatic vessels accompany the branches of the superior mesenteric artery and drain into nodes in the mesentery. The lymphatic vessels draining the small intestine called the **lacteals** carry the lymph as well as the fat globules and other absorbed material from the intestines. The lymph primarily drains into the peripheral group lying close to the wall of the intestine, which drain into the jejunal and ileal groups lying close to the arcades, which finally drain into the **superior mesenteric nodes** (7-11), lying around the origin of superior mesenteric artery.

Large intestine: four main groups of lymph nodes are seen:

- **Epicolic**: on the walls of the colon;
- **Paracolic**: on the inner margin of the colon;
- **Intermediate** group: along the branches of inferior mesenteric artery viz. Middle colic, sigmoidal and superior rectal and finally the
- **Central or terminal** called the **inferior mesenteric** nodes, lying around the origin of inferior mesenteric artery.

Efferents from the superior and inferior mesenteric nodes form **intestinal trunks**, which along with lumbar trunks enter the abdominal confluence of the lymph trunks at the level of L1-L2, called the **cisterna chyli** and then ascend as the **thoracic duct**.

Materials: Articulated skeleton, **Prosected specimens**: superficial and deep abdomen, celiac axis specimen, lateral pelvic wall specimen; **Models** Torso, models of sagittal male and female pelves, **X-Rays:** radiographs.

TUTORIAL/LABORATORY CLASS 13
LIVER, GALL BLADDER AND BILIARY TREE

Aims: To describe: the structure, function and relations of the liver; ligaments or the peritoneal folds attachments of the liver and surrounding structures; the gross anatomy and functions of gall bladder and biliary tree; the blood, nerve supply and lymphatic drainage of liver and gall bladder.

Specific Objectives

1. To describe the position of the liver, its lobes, surfaces and borders.
2. To recognise the porta hepatis and its contained structures and state the main features of the intrahepatic circulation.
3. To identify the peritoneal relationships of the liver and recognise the falciform, coronary and triangular ligaments, the lesser omentum and the so-called bare area of the liver.
4. To describe the relationship of the liver to the diaphragm, chest wall and costal margin.
5. To identify the relationships of the posteroinferior (visceral) surface of the liver.
6. To describe the blood and nerve supply to the liver and its lymphatic drainage.
7. To identify the position, gross features and immediate visceral relationships of the gall bladder.
8. To describe the blood and nerve supply to the gall bladder.
9. To identify the components of the extrahepatic biliary apparatus.
10. Describe the course and relations of the bile duct.

Learning activities

1. With colleagues study the gross anatomical features of the **liver** as detailed above in specific objectives 1 and 2 and discuss the structural basis of formation and flow of bile.

2. Several important relations or impressions are found on the visceral surface. Identify the following: **esophageal groove**, **gastric impression**, **pyloric area**, **duodenal impression**, **renal impression**, **colic impression, suprarenal impression, and fossa for gall bladder.** Also identify **fossa for IVC**.

3. Identify the **peritoneal ligaments** and **folds** attached to the liver. Identify **falciform ligament**, **coronary ligament** and its **superior** and **inferior layers**, and the **right and left triangular ligaments**. Identify the **bare area of the liver**. Observe and list the **parietal** and **visceral relations** of the liver.

4. Discuss the **blood** and **nerve supply** of the liver and its **lymphatic drainage**. Discuss the role of the **hepatic** and **portal circulations**.

5. With colleagues: participate in the **surface anatomy** of the liver and assess the uppermost level of the superior surface of the liver.

6. Identify the location, parts and internal features of the **gall bladder**. With colleagues, deduce and list the immediate visceral and body wall relations of the gall bladder and **bile duct**. Examine the **biliary apparatus** its parts and their relationship, arterial supply and venous drainage.

7. Identify the **portal vein** formed by the junction of **superior mesenteric and splenic veins**. Note that the **inferior mesenteric vein** drains into splenic vein.

8. Examine radiographs of cholecystography and ERCP (endoscopic retrograde cholangiopancreaticogram).

9. **Discuss clinical problems 32 and 33.**

Lecture Notes

1. **Liver:** Liver is the largest glandular organ in the body. *What really is the largest organ in the body? Note:* In males it generally weighs 1.4 to 1.8 kg and in females approximately 1.2 to 1.4 kg. Liver in an adult contributes to 2.5% of the body weight and 5% of the body weight of the fetus. The prominence of the potbelly appearance of a child is largely due to the large size of the liver.

Functions of the liver:

The liver has **endocrine or metabolic functions**: protein synthesis, glycogen storage, mineral and vitamin storage, production of clotting factors, detoxification of blood. It also has **exocrine functions**: secretion of bile by hepatocytes for release into the duodenum. Main functions of the liver include: store and filter blood; secrete bile into biliary system and performs a wide range of metabolic activities. Carbohydrates, proteins and lipids are metabolised in the liver. It produces bile salts and bile pigments. It is responsible for hemopoesis (production of blood cells).

Gross anatomy and external features:

The liver is a pyramidal shaped organ with its base to the right and apex to the left. The liver lies in the right hypochondrium, epigastrium and left hypochondrium. The liver has **diaphragmatic** and **visceral** surfaces. The diaphragmatic surface presents **superior**, **anterior** and **right surfaces**. The visceral surface of the liver is separated from anterior aspect of the diaphragmatic surface by a sharp inferior border. The liver is largely intraperitoneal except for a small area on the superior surface known as **the bare area**.

Diaphragmatic surface:

The **anterior** aspect of the diaphragmatic surface is triangular in shape, is completely covered by the visceral peritoneum and its relationships can be examined in two parts. Anterior aspect above the costal margin is related to the right dome of the diaphragm. Below the costal margin, extending from tip of 9th costal cartilage on the right to the tip of 8th costal cartilage on the left, the anterior aspect is in contact with the anterior abdominal wall. A sickle shaped double-layered fold of peritoneum called the **falciform ligament** extends from the anterior abdominal wall and divides the liver into larger **right** and smaller **left lobe**. The falciform ligament contains **round ligament of the liver** or **ligamentum teres** (see below) in its free edge.

The **posterior aspect** of diaphragmatic surface is related to the right dome of the diaphragm. There is a triangular area on this aspect enclosed between the **superior** and **inferior layers of coronary ligament** that lacks visceral peritoneal covering and lies directly in contact with the diaphragm and is called the **bare area of liver**. The bare area of liver is related to the right suprarenal gland.

Right aspect of the diaphragmatic surface is covered by visceral peritoneum and lies in contact mostly by the costal fibres of the diaphragm. *Note: This aspect of the liver is generally used for liver biopsies.*

Visceral/inferior Surface of the Liver

The visceral surface is in fact a posteroinferior surface and faces downwards, posteriorly and to the left. It is wedge-shaped and possesses two grooves (on the left), two fossae (on the right) and a fissure (in the middle) arranged in the form of H.

The right limb of **H** is made in the anterior part by the **fossa for gall bladder** and in the posterior part by the **fossa** or **groove for IVC**.

The left limb of **H** in the anterior part is made by **fissure for ligamentum teres** (fibrous remains of the umbilical vein of the fetus) and in the posterior part is made by **fissure for ligamentum venosum** (fibrous remains of the ductus venosus in the fetus.

The cross bar of the **H** is represented by a deep transverse fissure called the **porta hepatis**. Porta hepatis is approximately 5 cm long and contains (BHP): right and left hepatic ducts joining to form the **bile duct** (B); **hepatic artery** (H); and the **portal vein** (P).

Several important relations or impressions are found on the visceral surface:

- **oesophageal groove**
- **gastric impression**
- **pyloric area**
- **duodenal impression**
- **renal impression**
- **colic impression**
- **suprarenal impression**
- **gall bladder.**

Lobes of the liver:

The liver is divided into the **left** and **right** lobes by the **falciform ligament** on the anterior diaphragmatic aspect and the grooves for the ligamentum venosum and ligamentum teres on the visceral aspect. The right lobe is further divided into **quadrate** and **caudate** lobes by the fossa for gall bladder, fossa for inferior vena cava (IVC) and the porta hepatis.

Right lobe: is larger compared to the left, forms $5/6^{th}$ of the liver and comprises of the quadrate and caudate lobes. It can be seen on both diaphragmatic and visceral surfaces of the liver. The inferior surface of the right lobe of liver immediately to the right of the fossa for gall bladder, (related to the gall bladder) presents a **colic impression** that is related to the hepatic flexure of colon; a **duodenal impression** that is related to the second part of duodenum and a **renal impression** that is related to the upper pole of right kidney. Note that all these structures are retroperitoneal.

Left lobe: is smaller than the right lobe and forms $1/6^{th}$ of the liver. Note that the left lobe of the liver, on the inferior surface, near the fissure for ligamentum venosum, presents a **groove for abdominal esophagus** and a rounded elevation called **omental tuberosity** (tuber omentale) that is related to lesser omentum. The left lobe bears a deep concave depression called the **gastric impression** for the stomach

Caudate lobe is present on the posterior surface and lies between the fossa for IVC and the groove for the ligamentum venosum. It is bound inferiorly by the porta hepatis. It is often connected to the Rt lobe by a small tail like projection called the **caudate process**. On the left it may show an elevation called the **papillary process**.

Quadrate lobe is quadrangular in shape and lies on the inferior surface of the liver between the groove for the ligamentum teres on the left and the fossa for the gallbladder on the right. It is bound superiorly by the porta hepatis. It is related to the pylorus and first part of dudenum near the porta hepatis.

Reidel's lobe: Occasionally the lower border of Rt lobe to the right of the gall bladder, projects down as a broad linguiform (tongue-like) process and is called Reidel's lobe.

Fossa for the gall bladder:

Fossa for gall bladder can be considered as another bare area of liver as there is no visceral peritoneum over this part of the liver. It is occupied by the gall bladder (discussed below).

Fossa for inferior vena cava:

Fossa for inferior vena cava lodges the inferior vena cava and is pierced by three hepatic veins (right, left and middle). It is also related to the right suprarenal gland near the fossa for IVC and the bare area of liver.

Porta hepatis

Porta hepatis is a deep transverse fissure that lies between the caudate process of caudate lobe and the quadrate lobe. It contains the portal v., hepatic a., hepatic plexus of nerves (entering

the liver) and the Lt and Rt hepatic ducts (BHP) and some lymph vessels leaving the liver. The hepatic ducts are anterior and to the right, the hepatic a. proper and its branches are anterior and to the left and the portal v. and its branches are posterior. Porta hepatis gives attachment to the **hepatoduodenal ligament** from the **lesser omentum**.

Liver lobes versus Liver 'halves'

Liver lobes: The liver as we noted is divided into the Left and Right lobes by the falciform ligament on the diaphragmatic aspect and the grooves for the ligamentum venosum and ligamentum teres on the visceral aspect. Classically the quadrate and caudate lobes are a part of right lobe. This division is artificial if one considers the arterial and venous territories as well as the drainage of bile via hepatic ducts.

Liver halves: Note that the right and left branches of the hepatic artery supply the so-called '**halves**' of the liver, which are separated by a **principal plane**, and not the right and left lobes of the liver in the strict sense. The principal plane lies to the right of the classical division between right and left lobes and extends from the fossa for gall bladder to the fossa for IVC, thus making the caudate and quadrate lobes part of the left *half*, even though they are considered parts of the right *lobe*. The portal vein and hepatic duct also have left and right divisions, which serve the left and right halves.

Blood and nerve supply of the liver & lymphatic drainage:

Hepatic Vessels and Nerves

Hepatic artery proper: The liver is supplied by the **hepatic a. proper**, and drained by the **portal v.** Note that the bile duct, hepatic artery proper and portal vein lie in the free edge of the lesser omentum to reach the porta hepatis. The **bile duct** travels in the free edge of lesser omentum and is accompanied by lymphatic vessels. All these structures are ensheathed in the perivascular fibrous capsule (hepatobiliary capsule of Glisson), which is continuous with the fibrous capsule of the liver. The **hepatic artery proper** is a continuation of the **common hepatic artery** after it has given off the gastroduodenal artery. The hepatic artery proper gives off **right gastric artery** and enters the porta hepatis and divides into **right** and **left hepatic** arteries. Right hepatic artery supplies right half of the liver and also supplies the gall bladder via the **cystic** branch. The left hepatic artery supplies the left half of the liver including the quadrate and caudate lobes of the liver. The hepatic a. and its branches divide and subdivide in the liver are distributed in association with the branches of the portal vein. Within the liver the hepatic arteries and their branches form **segmental vessels**, which divide further to form the **interlobular vessels**. The interlobular vessels ultimately communicate with the **hepatic sinusoids**. Thus the arterial blood mixes with the portal venous blood in the hepatic sinusoids. *The branches of right and left hepatic artery do not anastomose with each other and they thus are end arteries*.

Portal vein: is formed by the union of superior mesenteric (SMV) and splenic veins behind the neck of the pancreas. The inferior mesenteric vein is a tributary of splenic vein but occasionally drain at the junction of SMV and Splenic vein.

Note: The **hepatic a.** brings oxygenated blood contributing to **30%** of the volume of blood to the liver. The **portal v**. brings approximately **70%** of hepatic blood, which contains: the nutrients absorbed in the gut, any toxic substances absorbed or produced by bacteria in the gut and poorly oxygenated blood.

Portal Triad: The branches of the hepatic a., portal v., and hepatic duct along with lymphatic vessels form the **portal triad** at the margins of the hepatic lobules. The portal triads are ensheathed in connective tissue called the portal canal or perivascular fibrous capsule).

Hepatic veins drain from the liver to the IVC. They drain blood from the central veins of the hepatic lobules. Hepatic sinusoids in the liver drain into interlobular veins, which ultimately form the hepatic veins draining deoxygenated blood from the gastrointestinal system into the IVC. The hepatic veins are usually arranged in two groups: **upper group** is made of three

very large venous channels: **right**, **left** and the **middle**. The **lower group** may have many small veins from right and the caudate lobes draining directly into IVC.

Hepatic lymphatics: can be divided into superficial and deep groups. The superficial group of lymphatic vessels run on the surface of the liver may drain across the diaphragm to the **internal thoracic** (mammary) and **diaphragmatic** lymph nodes to the **Rt lymphatic duct**, and/or thoracic duct directly; the deep lymphatics lie close to IVC may terminate into the **hepatic** and **gastric** nodes in the abdomen and thence to the **coeliac** nodes and ultimately the **thoracic duct**.

Nerve supply of the liver:

The **hepatic plexus** an extension of celiac plexus surrounds hepatic a. proper and contains sympathetic fibres (derived largely from the greater splanchnic n.) and parasympathetic fibres (derived from the anterior and posterior vagal trunks). These fibres enter the porta hepatis and accompany the blood vessels and bile duct.

2. **Peritoneal Attachments of the Liver**

Ligamentum teres: is an embryological remnant of the obliterated umbilical v. and connects the left branch of the portal v. to the umbilicus. This ligament runs in the free edge of the falciform ligament (discussed below) and has a groove called the **groove for ligamentum teres**, on the visceral surface of the liver. The umbilical v. was of major importance in fetal life as it carried all the blood from the placenta to the fetus. The oxygenated blood from the placenta reached the liver via umbilical vein, joined the left branch of portal vein, some blood passed through the liver to perfuse it, then via the bypass channel (ductus venosus) joined IVC to reach the right atrium of heart for circulation to the body.

Ligamentum venosum: is a remnant of ductus venosus (a bypass channel between the left branch of portal vein and the IVC) in the fetus. It lies in the fissure for ligamentum venosum that extends between the cuadate lobe and the left lobe and is bound superiorly by the porta hepatis. It gives attachment to the **hepatogastric ligament** from the **lesser omentum**.

Falciform ligament is a fold of peritoneum, which connects the liver to the diaphragm and the supraumbilical part of the anterior abdominal wall. It is attached to the anterior and superior surfaces of the liver and to the notch for the ligamentum teres. It contains the small paraumbilical veins and the ligamentum teres in its free edge. Its left layer continues as the anterior layer of the **left triangular ligament**, and right layer continues as the upper layer of the coronary ligament. The line of attachment of the falciform (together with the grooves for the ligamentum venosum and ligamentum teres) is said to divide the liver into left and right lobes.

Coronary ligament is a reflection of peritoneum from the diaphragm to the liver's superior and posterior surfaces. It has upper and lower layers, which are continuous at the right as the Rt triangular ligament and enclose the bare area of the liver. To the left the upper layer becomes the right layer of the falciform, while the lower layer becomes the posterior layer of the left triangular ligament. The lower layer of the coronary ligament may reflect onto the upper pole of the right kidney (as the hepatorenal ligament) instead of the diaphragm.

Left triangular ligament formed from left layer of the falciform and lower layer of the coronary as they meet at the left.

Right triangular ligament formed from the two layers of the coronary ligament meeting at the right.

Lesser omentum connects the liver to the stomach and 1st part of the duodenum (hepatogastric and hepatoduodenal ligaments). It inserts along the groove for the ligamentum venosum and encircles the porta hepatis. The groove for the ligamentum venosum contains the obliterated remnant of the ductus venosus, which in fetal life connected the left branch of the portal v. to the IVC, or the left hepatic v. just before it enters the IVC.

3. **Gall Bladder and Biliary Apparatus**

The Gall Bladder

This organ lies in the fossa for gall bladder on the visceral aspect of the liver. It has a capacity of about 30 to 50 ml. The gall bladder generally is covered on only one side by peritoneum, but in some individuals it may have its own mesentery.

Several **relations** may be identified as follows:

- **anterior**: anterior abdominal wall;
- **posterior**: first part of duodenum, cystic duct and porta hepatis; and
- **inferior:** transverse colon.

The gall bladder has several parts. Identify:

The **fundus** is the dilated part of gall bladder that protrudes below the inferior margin of the liver and lies in contact the anterior abdominal wall in the angle between the lateral margin of right rectus abdominis muscle and the posterior aspect of right 9th costal cartilage. It is surrounded by visceral peritoneum and is related posteriorly to the transverse colon and anteriorly to the anterior abdominal wall.

The **body** continues upwards from the fundus and lies in the fossa for gall bladder adherent to the inferior surface of the liver. It is covered by visceral peritoneum only on its visceral or inferior surface. This surface of the body is related to transverse colon and first & second parts of duodenum.

The **neck** is the narrow continuation of body and firstly curves anterosuperiorly and then posteroinferiorly to become continuous as the cystic duct. The neck is attached to the liver by loose areolar tissue, which contains the cystic a. and on its inferior surface it is related to the first part of duodenum. The neck of the gall bladder is constantly open due to the presence of a **spiral valve**.

Some authors describe a posteromedial dilation of the neck known as **Hartmann's pouch**, but this structure has been shown to be a consequence of pathological dilatation of the gall bladder and is not a normal anatomical structure. *It is of clinical importance as the gallstones may get lodged in the pouch.*

Biliary apparatus:

The Cystic Duct

This is 3 to 4 cm long and passes from the neck of the gall bladder to join the **common hepatic duct**, thus forming the **bile duct**. It usually joins the hepatic duct near the porta hepatis, but may join lower, so that the cystic duct then runs in the free edge of the lesser omentum. Its mucosa bears 5 to 12 crescentic folds, known as the **spiral valve**. These also may be found in the neck of the gall bladder (see above).

The Bile Duct

This is formed, usually near the porta hepatis, by the junction of the cystic and common hepatic duct. The bile duct is about 7.5 cm long and 6 mm wide. It has several important relations in its course. It descends posteriorly and slightly to the left anterior to the **epiploic foramen**, in the **free edge of the lesser omentum**. While in this structure the **portal v.** lies posteriorly to the left and the **hepatic a. proper** lies to the left. It then passes posterior to the **superior or 1st part of the duodenum**, with the **gastroduodenal a.** to its left and then runs in a groove on the posterior surface of the **head of the pancreas**. At this stage the posterior superior pancreaticoduodenal a. may spiral around it. Once it dives into the head of the pancreas the bile duct passes posterior to the accessory pancreatic duct. Finally, it joins the main pancreatic duct to form the **hepatopancreatic ampulla** (of Vater), the distal constricted part of which opens on the summit of the **greater (or major) duodenal papilla** (8 to 10 cm from the pylorus).

Sphincters of bile duct and associated structures:

Circular smooth muscle fibres around the lower end of the bile duct, including the ampulla and terminal pancreatic duct forms the **sphincter of the hepatopancreatic ampulla** (of **Oddi**) around the ampulla of Vater. There also are muscle sphincters at the termination of: at the end of the bile duct called the **choledochal sphincter**; and at the end of the pancreatic duct called the **sphincter of the pancreatic duct**.

Blood and nerve supply of the biliary system:

The **arterial supply** for the gall bladder is received from the **cystic a**. that is a branch from the **right hepatic** a. and it supplies, hepatic ducts and upper portion of the bile duct. The lower portion of the bile duct receives its blood supply from the posterior superior pancreaticoduodenal a.

Venous drainage of the gall bladder is directly to the liver, and that of the bile duct is via **cystic vein** that drains directly into the portal v.

Lymphatic drainage of gall bladder and biliary system: the lymph vessels draining the cystic duct, hepatic ducts and the proximal part of bile duct drain into **cystic node**. Cystic node is commonly enlarged in cholecystitis and most constantly is located in the angle between cystic duct and the common hepatic duct at the formation of bile duct. The lower part of bile duct drains into **hepatic** and **pancreaticosplenic** lymph nodes. Ultimately the lymph drains to the coeliac nodes.

Nerve supply is by the coeliac plexus along the arteries supplying the liver.

4. Examine the X-ray of the gall bladder and **cholecystography**.

Materials: **Models** torso, liver; **prosected specimens:** superficial and deep abdomen, celiac axis specimen, duodenum, pancreas and spleen (for greater duodenal papilla), prosected specimens of liver; **X-Rays:** radiographs.

TUTORIAL/LABORATORY CLASS 14
BLOOD VESSELS, LYMPHATICS AND NERVES OF THE ABDOMEN AND PELVIS

Aim: To understand the blood supply of the abdomen and pelvis; identify the course, relationships, termination and branches of the abdominal aorta; revise blood supply of GIT; identify the IVC and its tributaries; identify the autonomic plexuses related with the abdominal and pelvic organs.

Specific Objectives

1. To summarise the principles of blood supply to abdominal and pelvic viscera.
2. To describe the formation of inferior vena cava and its tributaries: the common iliac, gonadal, renal, suprarenal, inferior phrenic, lumbar and hepatic veins.
3. To identify and name the portal vein and its tributaries. To describe the significance of portal-systemic anastomosis.
4. To identify the position of the lumbar plexus and its branches as follows: iliohypogastric and ilioinguinal nerves, femoral nerve, obturator nerve, lumbosacral trunk, and the genitofemoral nerve.
5. To summarise the principles of innervation of the abdominal viscera, naming the principal visceral plexuses involved. Define the position of coeliac, renal, superior and inferior mesenteric, aortic and superior hypogastric autonomic plexuses.

Learning activities

1. **With colleagues, identify the major blood vessels and nerves as listed in the lecture notes of this lab class.**

2. Identify *visceral* and *parietal* branches of **abdominal aorta**. Identify the termination of abdominal aorta and the **right** and **left common iliac arteries**. Note that the common iliac artery on each side divides into **external iliac** and **internal iliac arteries**.

3. Identify the branches of the **coeliac trunk**: the **left gastric**, **splenic** and **common hepatic artery** and discuss their distribution.

4. Identify the major branches of the **superior and inferior mesenteric arteries**
5. Identify the following branches of the **internal iliac artery**: **iliolumbar, lateral sacral, superior and inferior gluteal, internal pudendal, umbilical and obturator**.
6. Identify the main tributaries of the **inferior vena cava** and identify the sites of portacaval anatomoses and anastomoses between inferior and superior epigastric veins.
7. Identify the **portal vein** and its tributaries. Discuss the portal-systemic anastomoses.
8. With colleagues, identify the thoracoabdominal nerves and their distribution. Identify the **lumbar plexus** and its branches: **subcostal**, **iliohypogastric**, **ilioinguinal**, lateral cutaneous nerve of thigh, **genitofemoral**, femoral and obturator nerves.
9. With colleagues examine the autonomic nerve supply of the abdomen. In the thorax identify the **vagus nerves**, anterior and posterior vagal trunks on the lower part of the oesophagus. Identify the **greater** and **lesser splanchnic nerves**. In the abdominal cavity identify the **coeliac**, **aortic** and **superior hypogastric plexuses**, the **right** and **left hypogastric nerves** and the **sympathetic trunk** and its **ganglia**. Identify the **lumbar splanchnic nerves**.
10. Discuss the parasympathetic and sympathetic supply to the abdominal viscera.
11. **Discuss clinical problem 36.**

Lecture Notes

1. Arterial Supply Of The Abdomen

The Abdominal Aorta

The abdominal aorta extends: from the abdominal aortic hiatus deep to the median arcuate ligament of the diaphragm, at TV12; to its bifurcation into the common iliac aa., at LV4-LV5.

Relations of abdominal aorta:

The abdominal aorta is a retroperitoneal structure that is related

Anteriorly from superior to inferior:

- Celiac plexus
- Body of pancreas
- Left renal vein
- Uncinate process of pancreas
- Horizontal part of duodenum
- Root of mesentery

Posteriorly it is related from superior to inferior:

- Lumbar vertebrae with intervertebral discs and ligaments

On the right:

- Cisterna chili
- Right crus of diaphragm
- Inferior vena cava

On the left:

- Left crus of diaphragm
- Duodenojejunal flexure
- Left sympathetic trunk

Branches of abdominal aorta:

The abdominal aorta has four groups of branches: ventral and lateral (distributed to the abdominal viscera), posterior and terminal (distributed to the abdominal wall).

The **Ventral (unpaired)** branches include: the **celiac**, **superior mesenteric** and the **inferior mesenteric** arteries.

The **lateral (paired)** branches include: the **inferior phrenic**, the **middle suprarenal**, the **renal** and the **gonadal (ovarian or testicular)** arteries.

Posterior (paired and unpaired) branches include: **lumbar** (paired) and the **median sacral** (unpaired) arteries. **Terminal (paired):** the right and left **common iliac**. arteries

The Ventral Branches: These have already been dealt with in sections on the gastrointestinal tract.

The Coeliac Trunk

The coeliac trunk is the artery of foregut and hence supplies stomach, part of duodenum proximal to the greater duodenal papilla, liver, pancreas and spleen. It arises at the level of T12, is very short (only about 1.25 cm long) and divides into three main branches. It may also give off the inferior phrenic aa.

- **Lt gastric a.**
- **Common hepatic a.**
- **Splenic a.**

The **left gastric a.** is the smallest branch of coeliac trunk, it ascends to the left posterior to the lesser sac and as it reaches the esophagus it gives off 2 or 3 **esophageal** brr. Left gastric artery the descends between the layers of lesser omentum, close to the lesser curvature and supplies the anterior and posterior surfaces of the body of stomach. At its termination it anastomoses with the right gastric branch of hepatic artery proper

The **common hepatic a.** accompanied by the hepatic plexus travels downwards, forwards and to the right, to reach the first part of the duodenum. At this point the common hepatic artery divides into:

The **hepatic a. proper** crosses anterior to the portal vein and then runs in the free edge of lesser omentum to reach the porta hepatis. Here it divides into **Lt and Rt hepatic a**. The right hepatic also gives off the **cystic a.** to the gall bladder.

The **gastroduodenal a.** descends vertically and deep to the first part of duodenum and superficial to the neck of pancreas and at the lower border of duodenum divides into: **Rt gastroepiploic** and **superior pancreaticoduodenal a**. The superior pancreaticoduodenal artery divides into **anterior** and **posterior brr**, supplying the anterior and posterior surfaces of duodenum and pancreas as far as the greater duodenal papilla (which marks the boundary between foregut and midgut). These branches anastomose with similar branches of inferior pancreaticoduodenal artery from the superior mesenteric artery. **Right gastroepiploic artery** after its origin from gastroduodenal artery runs to the left between the layers of greater omentum, anastomoses with the left gatrepiploic artery from splenic artery and supplies the body and pyloric antrum of stomach on anterior and posterior aspect.

Rt gastric a. arises from hepatic artery proper superior to the duodenum. It supplies a branch to the duodenum, travels to the left between layers of lesser omentum, anastomoses with left gastric artery and supplies both anterior and posterior surfaces of the lesser curvature of the stomach and pylorus.

The **splenic a.** is the largest br of the coeliac trunk travels to the left deep to the lesser sac and posterior to the body of stomach along the superior border of the pancreas. It is accompanied by splenic vein and provides several brr:

- Pancreatic brr including the pancreatica magna artery along the superior border of pancreas.
- **Short gastric aa** (5 to 7 in number), ascend up travel through gastrosplenic ligament and supply the gastric fundus and far left greater curvature.

- Posterior gastric a. described by some authors as arising from the splenic a. at its middle section (present in 58% of cadavers). It ascends towards the fundus supplying the posterior gastric wall.
- **Lt gastroepiploic a.** travels between the layers of gastrosplenic ligament then descends inferiorly along the greater curvature within the layers of greater omentum and supplies the greater curvature and left part of greater omentum.
- **Terminal splenic brr.** are end arteries, enter through the hilum of spleen.

The superior mesenteric artery

The superior mesenteric artery (SMA) arises from the abdominal aorta at the level of transpyloric plane at L1 vertebra and is the artery of midgut. The superior mesenteric artery travels in the root of mesentery from the level of Lv2 vertebra to the right sacroiliac junction. At its origin it passes in front of the left renal vein, uncinate process of pancreas and third part of duodenum accompanied by the superior mesenteric vein on its right side. SMA crosses in front of IVC, right ureter and psoas major muscle to reach the right iliac fossa. It supplies the second part of duodenum (from the greater duodenal papilla), jejunum, ileum, caecum, appendix, ascending colon and the transverse colon as far as the left trisection.

Branches of superior mesenteric artery:

a) Superior mesenteric a.: Branches of SMA include:

Inferior pancreaticoduodenal, which gives of anterior and posterior brr that anatomose with similar branches of superior pancreaticoduodenal artery.

Jejunal and **ileal brr,** 18-20 branches arise from the left side of the SMA, travel in the layers of mesentery and supply the jejunum and ileum.

Ileocolic is a branch that arises from the right side of the SMA and travels posterior to the peritoneum of the posterior abdominal wall. It gives off the **appendicular** a. (traveling in the mesoappendix), **anterior** and **posterior caecal** arteries and the **colic** branch. Terminal part of ileocolic artery anastomoses with ileal branch of SMA.

Right colic travels behind peritoneum on the posterior abdominal wall and divides into ascending and descending brr that supply ascending colon, and

Middle colic artery arises from the anterior aspect of SMA and ascends in the transverse mesocolon. It divides into right and left branch that supply transverse colon.

Inferior mesenteric a.:

The inferior mesenteric a. arises from the abdominal aorta at the level of L3 and is the artery of hindgut. It supplies the left 1/3 of the transverse colon, descending colon, sigmoid colon, rectum and anus as far as the pectinate line. It gives off:

Left colic artery that runs to the left divides into ascending and descending branches and supplying transverse and descending colon.

Sigmoidal brr. two or three, descend downwards and each divides into ascending and descending branches and supply the descending colon and the sigmoid colon.

Superior rectal is a direct continuation of inferior mesenteric a. traveling in the sigmoid mesocolon. Opposite the level of SV3 divides into two branches behind the rectum and supply the rectum one from each side. These arteries anastomose with middle rectal from internal iliac and inferior rectal from internal pudendal artery.

Arterial anatomoses: Note branches of coeliac trunk, and superior mesenteric and inferior mesenteric arteries **anastomose** with each other and with other branches of the aorta. Following are some of the anastomoses:

1. Branches of the left gastric a. anastomoses with aortic oesophageal brs around the lower oesophagus.

2. Anterior and posterior superior pancreaticoduodenal aa (coeliac trunk) anastomoses with inferior pancreaticoduodenal (superior mesenteric br) around the head of the pancreas and 2nd part of the duodenum.
3. **"Marginal"** artery is formed as a result of anastomosis between the colic branch of **ileocolic**, the ascending and descending branches of **right colic**, right and left branches of **middle colic** from the superior mesenteric and ascending and descending branches of **left colic**, and **sigmoidal** branches from the inferior mesenteric.
4. Superior rectal a. from inferior mesenteric a. anastomoses with middle rectal from internal iliac and/or inferior rectal from internal pudendal (from internal iliac).

The Lateral (paired) Branches of Abdominal Aorta:

The inferior phrenic a.

These two small arteries arise at the level of T12 and help to supply the diaphragm and some small parts of the suprarenal glands, liver and spleen. They may arise separately from the aorta or by a common stem from the aorta or from the coeliac trunk. Each artery ascends anterior to the right and left crus of the diaphragm medial to the suprarenal gland. These arteries anastomose with the musculophrenic, posterior intercostal and pericardiacophrenic aa. They give off the **superior suprarenal aa.**

The middle suprarenal a.

These arise at L1 vertebral level along with the superior mesenteric a. The artery on the Rt passes behind the IVC. Both are related to the coeliac ganglia of the respective sides. They anastomose with the suprarenal brr of the inferior phrenic and renal aa.

The renal a.

These are a pair of large arteries branch from the aorta just below the level of the superior mesenteric a. at L1 vertebral level. The Rt renal artery is longer and often higher, passing posterior to the IVC, RT renal v., body of the pancreas and descending part of the duodenum. The Lt renal artery passes behind the Lt renal v., body of the pancreas and splenic v. Each renal artery divides into 4 or 5 branches that supply the kidney and supplies the ureter in its upper extent. Each renal artery gives off **inferior suprarenal arteries** that supply the suparenal glands in part. One or two accessory renal aa often occur, arising above or below the renal aa.

The testicular a.

The pair of testicular arteries arises from the abdominal aorta anteriorly slightly inferior to the renal a. at the level of L2 in males. Each passes anterior to the psoas major behind the parietal peritoneum. Each passes to the deep inguinal ring to enter the inguinal canal to travel in the spermatic cord, finally passing to the scrotum. The testicular a. supplies: the testis, perirenal fat, ureter, iliac lymph nodes and cremaster.

The ovarian a.

The pair of ovarian arteries in females is homologous to testicular aa in males but enter the pelvis to supply the ovary. They enter the suspensory ligament of the ovary to continue into the broad ligament of the uterus. They give off brr to supply: the ovary, ureter, uterine tubes and one branch passes to the side of the uterus to anastomose with the uterine a. Other brr of ovarian artery accompany the round ligament of the uterus to the inguinal region and supply the skin of the labium majus.

The Dorsal Branches of abdominal aorta:

The lumbar aa.

There are usually **four** pairs of lumbar arteries (first, second, third and fourth) on each side. They pass anterior to the 4 upper lumbar vertebral bodies, pass behind the sympathetic trunks to supply the posterior abdominal wall. The Rt lumbar arteries pass posterior to the IVC. Each artery has *spinal* (to the vertebral canal and contents), *ventral* (to body wall) and *dorsal* (to dorsal muscles, joints and skin) branches.

The median sacral a.

This is a single small posterior branch, which leaves the aorta slightly above its bifurcation and descends anteriorly to the midline of LV4, LV5, the sacrum and ends at the coccyx.

The Terminal Branches of Abdominal Aorta:

The abdominal aorta bifurcates anterior to the left side of disc between the LV4 and LV5, into right and left **common iliac aa**. Right and left common iliac arteries are crossed by the hypogastric plexus and right and left hypogastric nerves. These diverge to bifurcate near the level of the lumbosacral intervertebral disc into **external** and **internal iliac aa**. The iliac arteries lie deep to the peritoneal covering and are accompanied by the corresponding iliac veins,

The External Iliac Artery:

The external iliac a. travels on the medial border of psoas major muscle and is related to the pelvic brim gives off the **inferior epigastric a.** just proximal to the inguinal ligament. The inferior epigastric artery ascends medial to the deep inguinal ring raising the parietal peritoneum as it does so to form the **lateral umbilical fold** to pierce the transversalis fascia and passes anterior to the posterior layer of the rectus sheath. Within the rectus sheath it divides into numerous branches, which anastomose with the **superior epigastric** and **posterior intercostal aa**.

The external iliac also gives off a **deep circumflex a.**, which arises almost opposite the inferior epigastric and ascends the iliac crest anstomosing with the ascending br of the lateral circumflex femoral, lumbar and inferior epigastric aa. The other brs of the external iliac (for the leg) are dealt with in another course.

The Internal Iliac Artery:

The internal iliac artery commences in front of sacroiliac joint and reaches the upper border of greater sciatic notch/foramen. It lies anterior to the internal iliac vein and lumbosacral trunk, medial to obturator nerve, is crossed by the ureter in both sexes and in females also by the ovarian vessels.

The internal iliac artery divides at the upper border of greater sciatic foramen into **anterior and posterior trunk** or **divisions**, although this clear separation is often not apparent in our specimens.

Branches from the anterior trunk are mainly visceral branches (except obturator, internal pudendal and inferior gluteal aa) and include:

Umbilical artery: Derived from the umbilical a of the fetus

- Runs on the lateral wall of the pelvis
- Gives off 2-3 **superior vesical aa.**, which supply the urinary bladder
- In the Male: artery to ductus deferens, which also supplies the ureter.
- After giving the last superior vesical branch the umbilical artery is occluded and becomes continuous as the **obliterated umbilical artery** or the **medial umbilical ligament**. It travels towards the umbilicus and raises a fold of peritoneum on the deep surface of the anterior abdominal wall called the **medial umbilical fold**.

Obturator a.

- Leaves the pelvis via the obturator foramen and canal to supply the muscles and skin of medial thigh.
- It is accompanied by the obturator vein and nerve.

Uterine a.

- Runs medially towards the cervix of uterus and crosses the ureter in the transverse cervical or cardinal ligament.
- After reaching the lateral wall of the cervix the uterine artery enters the broad ligament and ascends up to supply the uterus. It reaches the uterine tube and supplies the uterine tube and may also supply the ovary.

Vaginal a.

- Arises inferior to the uterine artery, lies below the ureter and reaches vagina.

- (vaginal a. is homologous to the inferior vesical a of males);

Inferior vesical a.

- Replaces vaginal artery of the female and
- Supplies seminal vesicles, ampulla of ductus deferens and prostate gland.

Middle rectal a.

- Gives branches to the rectum, anastomoses with superior rectal and inferior rectal arteries.
- In the males it also supplies prostate and seminal vesicles.
- In the females it also supplies vagina.

Internal pudendal a.

- Leaves the pelvis between the piriformis and coccygeus muscles.
- It passes deep to the sacrotuberous lig.
- It passes just above and hooks around the ischeal spine
- Enters the pudendal canal in the lateral wall of the ischiorectal fossa.
- It has several **branches**: muscular brr, **inferior rectal a.**, **perineal** a., **artery of the bulb of the penis** (in males), **artery of the bulb of the vestibule** (in females), **urethral** a., **dorsal a. of the penis** (males), **dorsal a. of the clitoris** (females), **deep artery of the penis** or **clitoris**, and **scrotal** or **labial** brr.

Inferior gluteal a.

- It passes between S1 and S2 ventral rami
- It leaves the pelvis below the piriformis through the greater sciatic foramen.

Branches of the posterior trunk include:

Iliolumbar artery

- Runs upwards and laterally across the lumbosacral trunk and sacroiliac joint.
- Ascends to the medial border of psoas major and
- Divides into two branches that supply iliacus m. and the fifth lumbar artery

Lateral sacral aa

- Generally two: superior and inferior brr.
- Enter through ventral sacral foramina to exit through the dorsal sacral foramina and supply the muscles and skin on the posterior surface of sacrum.

Superior gluteal a.

- Is the largest branch of internal iliac artery
- It runs between lumbosacral trunk and S1 ventral ramus.
- Leaves the greater sciatic foramen above the piriformis.
- It supplies the muscles of the buttock

2. Venous Drainage Of The Abdomen

The venous drainage of abdomen and pelvis is accomplished by i) portal circulation for gastrointestinal system and ii) systemic veins for the somatic and extraperitoneal part of body.

Portal Circulation

Portal circulations by definition possess two sets of exchange capillaries. In this case one is in the digestive tube, spleen, pancreas and gall bladder and the other is in the liver sinusoids.

The portal V. is about 8 cm long and valveless, as are its tributaries in adult life. It begins at about the level of LV2 by junction of the **splenic v.** and **superior mesenteric v.** Its relations have already been dealt with in the liver lecture. As it reaches the porta hepatis it divides into **Rt and Lt branches**. The Rt br. supplies the right half of the liver and usually receives the cystic v. The Lt br. divides into brs to the caudate, quadrate and left lobes. As the Lt br. enters the liver it is

joined by paraumbilical vv, the ligamentum teres (remnant of the Lt umbilical v.) and is connected to the IVC by the ligamentum venosum (obliterated remnant of the ductus venosus).

Tributaries of the portal v. are the **splenic**, **superior mesenteric**, **Lt gastric**, **Rt gastric**, **paraumbilical** and **cystic Vs**.

The **splenic v**. has several tributaries: viz. the short gastric, the left gastoepiploic, the pancreatic and the inferior mesenteric (receives the Lt colic and sigmoid vv)

The **superior mesenteric v.** has several tributaries: the right gastroepiploic, the pancreaticoduodenal, the jejunal, the ileal, ileocolic, Rt colic, and the middle colic.

Portal-systemic anastomosis: Several portal-systemic anastomoses have been identified:

Site	Portal tributaries	Systemic tributaries
oesophagus	Lt gastric oesophageal brs	oesophageal brr to azygos and accessory hemiazygos vv
umbilicus	lig teres vv (paraumbilical)	epigastric vv
anal canal	superior rectal vv	middle and inferior rectal vv
retroperitoneal	venous radicles of colon ascending and descending colon and bare area of liver	retroperitoneal vv
liver	patent ductus venosus (br of Lt portal v.)	IVC

Portal hypertension:

Raised pressure in the portal circulation (portal hypertension) due to fibrosis and disordered regeneration of the liver (as occur in liver cirrhosis) can lead to retrograde flow from the portal tributaries to the systemic circulation. As a consequence these patients will have oesophageal varices (with the hazard of *hematemesis* = vomiting blood and/or *malaena*=dark stools), *caput Medusae* on the anterior abdominal wall and severe *internal haemorrhoids*.

Systemic Veins: This consists of the inferior vena cava and its tributaries in the abdomen:

The Inferior Vena Cava (IVC):

The IVC returns blood from lower limbs, pelvis anterior and posterior abdominal walls and the abdominal and pelvic viscera. It also receives the venous blood returned from the portal vein. It begins opposite the body of L5 vertebra to the right of midline. It ascends on the right lateral aspect of the bodies and intervertebral discs of the lumbar vertebrae and closely related to the aorta on its left. More proximally it lies on the right crus of diaphragm and passes through inferior vena caval hiatus in the central tendon of diaphragm at the level of T8.

Relations:

Posterior:

- Right lumbar part of sympathetic trunk

- Right renal and middle suprarenal arteries
- Right suprarenal glands

Anterior from inferior to superior

- Rt common iliac artery
- Mesentery and SM vessels
- Rt gondal a.
- Horizontal part of duodenum
- Head of pancreas and bile duct
- Portal vein and epiploic foramen
- Right lobe of liver

Tributaries: The IVC has several tributaries:

- **The lumbar vv**: (4 pairs) draining the lumbar region and posterior abdominal wall. Near the vertebral column they drain the vertebral venous plexus and are connected by the ascending lumbar v to the common iliac and iliolumbar vv.
- **The testicular vv:** (in males) drain the epididymis and testis, unite to form the pampiniform plexus and ascend with the testicular a. to enter the IVC just below the renal vv (Rt testicular vein) or Lt renal v. (Lt testicular v.).
- **The ovarian vv:** (in females) arise from a plexus in the broad ligament to ascend with the ovarian a. much like the testicular vv.
- **The renal vv.:** The Lt renal v. receives the **Lt gonadal vv** (ovarian or testicular), as well as the **Lt suprarenal v**.
- **The Rt suprarenal v**. drains directly into IVC.
- **The inferior phrenic vv**.: on the right drains directly in the IVC and on the left drains into left renal vein.
- **The hepatic vv** enter the IVC as it passes through the superior aspect of the liver.
- There are two major opportunities for collateral circulation: a) between the superior and inferior epigastric vv. and b) between the lumbar vv and vertebral venous plexus.

3. Nerve Supply of The Abdomen:

I) Autonomic Supply

Revise the principles of the autonomic nervous system from the first lecture in this course. Note the autonomic supply to the abdomen and pelvis is divided into **sympathetic** and **parasympathetic** components.

The sympathetic supply: Remember greater splanchnic n. (T5 to 9); lesser splanchnic n. (T9 to 10); lowest (least) splanchnic n. (T12); lumbar splanchnic nn (L1 to 3); and the sacral splanchnic nn.

The parasympathetic supply: Revise the vagus n. and the pelvic splanchnic nn. (S2-S4).

Autonomic plexuses:

These project to the prevertebral plexuses, which are situated anterior to the aorta and vertebral column.

Coeliac plexus:

Also called **solar plexus** contains the paired coeliac ganglia and is sited at the level of the last thoracic and 1st lumbar vertebra. It surrounds the root of the coeliac trunk and superior mesenteric a. The plexus and ganglia receive preganglionic sympathetic via greater and lesser splanchnic nn, and pregangionic parasympathetic via posterior vagal trunk containing fibres from both right and left vagus nerves. In addition fibres of vagus phrenic n. also join the plexus.

Coeliac plexus continues as **hepatic plexus** on hepatic artery, **Left gastric plexus** on left gastric artery and **splenic plexus** on splenic artery.

The **coeliac ganglia** are paired structures, which lie between the suprarenal glands and the coeliac trunk origin. The lower part is partially detached and is sometimes known as the **aorticorenal ganglion** as it forms most of the renal plexus.

Secondary plexuses derived from or connected with the coeliac are the phrenic, splenic, left gastric, **intermesenteric,** suprarenal, renal, gonadal, **superior mesenteric**, **inferior mesenteric** and **aortic plexus**.

Superior mesenteric plexus:

- Is a downward extension of the coeliac and consists of a **superior mesenteric ganglion or ganglia**, at the origin of the superior mesenteric artery.
- This plexus receives contributions of sympathetic fibres from the coeliac plexus and the lumbar ganglia of sympathetic chain via the right and left lumbar splanchnic nerves derived from the L1 and L2 levels of spinal cord.
- The parasympathetic component is derived mainly from the coeliac branch of the posterior vagal trunk.
- The branches of superior mesenteric plexus are distributed along the branches of the the superior mesenteric artery to the pancreas, small intestine, large inteerstine as far as the left one third of the transverse colon.

Intermesenteric (abdominal aortic plexus) plexus:

- Supplies the inferior vena cava, and the testicular plexus as well as connecting the superior nad in ferior mesenteric plexuses.

Inferior mesenteric plexus:

- Inferior mesenteric plexus consists of a fairly constant inferior mesenteric ganglion.
- It receives sympathetic fibres by a medial root from the intermesenteric plexus & lateral roots from the second and third lumbar splanchnic nerves from the lumbar sympathetic trunks.
- It receives parasympathetic fibres (S2, S3, S4) from the inferior hypogastric plexus in the pelvis.
- The plexus is distributed along the branches of the inferior mesenteric artery, from the left 1/3 of the transverse colon to recto-anal junction and to all the pelvic viscera
- Parasympathetic stimulation increases motility and glandular activity, and is inhibitory to the major sphincters.

Aortic plexus:

- Connects inferior mesenteric plexus with the **superior hypogastric plexus**, which is situated anterior to the aortic bifurcation, LV5 and the sacral promontory.
- The superior hypogastric plexus is formed from branches from the aortic plexus, 3rd and 4th lumbar splanchnic nn. (L1 and L2).
- It divides into **Lt** and **Rt hypogastric nn**, which descend on right and left sides to form to the **right** and **left inferior hypogastric plexuses**, lying anterior to the sacrum.

The inferior hypogastric plexus

- Also called the **pelvic plexus** and lies against the lateral walls of the pelvis.
- Is formed from preganglionic parasympathetic via **pelvic splanchnic nn** (from the S2 to S4). These nerves enter the pelvis via ventral rami of sacral plexus.
- It receives sympathetic nerves from the sacral splanchnic nn.
- Several plexuses arise from the inferior hypogastric or the pelvic plexuses:
    - middle rectal plexus,
    - vesical plexus,
    - prostatic plexus, and the
    - uterovaginal plexus.

Individual autonomic plexuses:

The phrenic plexus accompanies the inferior phrenic a. to the diaphragm and suprarenal gland.

The hepatic plexus is the largest coeliac derivative and receives filaments from both the left and right vagus nerves as well as the phrenic nn. It accompanies the hepatic a. and the portal v. and their branches into the liver and supplies the cystic plexus to the gall bladder. Branches may also supply the pylorus and greater curvature of the stomach as well as the lower bile duct, pancreatic head and 1st and 2nd parts of the duodenum.

The **Lt gastric plexus**: to the lesser curvature of the stomach.

The **splenic plexus**: is formed by branches of the coeliac plexus, left coeliac ganglion and Rt vagus and supplies the blood vessels and smooth muscle of the splenic capsule and trabeculae.

The **suprarenal plexus:** all the remaining preganglionic fibres from thoracic splanchnic nerves that have not synapsed in coeliac, superior mesenteric or aorticorenal ganglion reach the medulla of the suprarenal gland. Here they synapse in the chromaffin cells of the adrenal medulla and produce the same effect as the stimulation of the sympathetic system, except this time it is centrally by release of adrenaline and noradrenalin hormones in blood.

The **renal plexus**: is formed by fibres from the **coeliac ganglion and plexus, aorticorenal ganglion**, lowest thoracic splanchnic n., 1st lumbar splanchnic n. and aortic plexus. It gives off ureteric and gonadal plexuses.

The **ureteric plexus:** accompanies the ureter and the gonadal plexuses (ovarian or testicular) accompany the appropriate artery to their respective organs.

The superior mesenteric plexus: is a downward extension of the coeliac, which accompanies the superior mesenteric a. to pancreas, small intestine, large intestine as far as the Lt 1/3rd of the transverse colon.

The abdominal aortic plexus: (including the **intermesenteric**) supplies the IVC, and testicular plexuses as well as connecting the superior and inferior mesenteric plexuses.

The inferior mesenteric plexus receives supply from the aortic plexus and 2nd and 3rd lumbar splanchnic nn. It supplies the colon from the left trisection of the transverse colon to the rectum.

Summary of Segmental Sympathetic Supplies

oesophagus (caudal part)	T5 to 6
stomach	T6 to 10
small intestine	T9 to 10
large intestine to splenic flexure.	T11 to L1
splenic flex. to rectum	L1 to 2
liver and gall bladder	T7 to 9
spleen	T6 to 10
pancreas	T6 to 10
kidney	T10 to L1
suprarenal	T8 to L1
gonads	T10 to 11
urinary bladder	T11 to L2
uterus	T12 to L1

Enteric nervous sysytem

- Is a network of sensory neurons, relay nourons, motor neurons in the walls of GIT.
- Fuction:
    - controls complex reflex activity in lengths of small intestine
    - generates many of the complex movements of mixing and transport
    - controls processes of secretion along with a number of local hormones.
    - the sympathetic and parasympathetic postganglionic fibres form a network and modulate the activity of the intestine.

- Interestingly the heart will continue to beat even after all its ANS fibres have been cut. It has highly specialized cardiac muscle cells that initiate cardiac impulse. ANS modulates the rate and force of contraction.
- Similarly segments of intestinal tract will continue to produce peristalsis when removed from the rest of GIT.

Visceral Afferent:

- Visceral sensory systems is intermingled with the autonomic nervous system.
- Parasympathetic nerves are responsible for generating normal activity of the viscera. Visceral afferents, may travel with parasympathetic system via vagus nerves and pelvic splanchnic nerves (craniosacral origin).
- Pain fibres from viscera also pass to spinal cord in the sympathetic nervous system.
- Visceral sensations which are consciously appreciated are of two general kinds
  - visceral pain
  - visceral distension
- **Visceral pain** fibres accompany sympathetic fibres.
- Pain is experienced about the midline.
- Pain from viscera is referred to the skin in the midline of the anterior abdominal wall.
  - Foregut pain is felt around the epigastric region.
  - Midgut pain is felt in the umbilical region.
  - Hingut pain is felt in the hypogastric (pubic) region.
- **Visceral distention** for example from stomach, rectum and urinary bladder, gives rise to pain and this pain is perceived via the parasympathetic nerves.

The Somatic Supply

The thoracoabdominal nn

These are anterior and lateral brr of T6 to 11 intercostal nn, subcostal nerves and are motor to the anterolateral abdominal wall muscles, sensory to the anterolateral abdomen, gluteal region and lateral side of the thigh. T10 supplies the umbilicus, T12 supplies a strip halfway between the umbilicus and pubic symphysis, T8 supplies a strip halfway between the umbilicus and xiphoid process.

The phrenic n

This is from C3, 4, 5 and supplies the diaphragm and related pleura and peritoneum (motor and sensory).

Subcostal nerve: (T12, Pair)

- Ventral ramus of T12 spinal nerve
- Passes from thorax to the abdomen deep to the lateral arcuate ligament
- Courses inferior to the twelfth rib hence the name
- It lies in the order of VAN from superior to inferior
- Travels deep to the kidneys
- Pierces transverses abdominis muscle
- Supplies motor brr to anterolateral abdominal wall muscles and the skin of the abdomen midway between umbilicus and pubic symphysis

The lumbar plexus

This extends from spinal nerves L2 to L4, but branches of L1 are often considered with the lumbar plexus. L4 and L5 contribute to the sacral plexus by the **lumbosacral trunk**. There are several nerves to consider here, but their main significance for this course is as 'backdrop' or important posterior relations for visceral structures: the **iliohypogastric n.** and **ilioinguinal n. (L1)**; **genitofemoral n. (L1, 2)**; **lateral femoral cutaneous n. (L2, 3)**; **femoral n. (L2, 3, 4)**; and the **obturator n. (L2, 3, 4)**

Iliohypogastric nerve (L1, Pair)

- Ventral ramus of L1 spinal nerve
- Emerges from the lateral border of psoas major muscle

- Passes posterior to the kidney
- Pierces transverses abdominis muscle and runs parallel to inguinal ligament
- Supplies motor brr to mm of anterolateral abdominal wall, skin of buttock and skin over pubic region.

Ilioinguinal nerve (L1, Pair)

- Ventral ramus of L1 spinal nerve
- Emerges from the lateral border of psoas major muscle
- Pierces the lower part of internal oblique muscle and enters the inguinal canal
- Emerges through the superficial inguinal ring
- Supplies motor brr to internal oblique and transverses abdominis mm.
- In males: emerges in front of the spermatic cord and supplies skin of the anterior part of scrotum and penis.
- In females: supplies skin of labia major and mons pubis.
- Injury to the nerve may cause weakening of conjoint tendon and subsequent possibility of occurrence of inguinal hernia.

Genitofemoral nerve

- Ventral rami of L1-L2 spinal nerves.
- Pierces the front of psoas major muscle
- It is crossed by ureter, gonadal vessels, iliocolic artery on the right
- It is crossed by superior rectal artery on the left side.
- It divides into genital and femoral branches.
- The genital branch enters the inguinal canal through deep inguinal ring and passes through the spermatic cord. In males: it supplies cremaster and dartos muscles and skin of scrotum. In females it supplies labia majora.
- The femoral branch travels in front of femoral artery and supplies the skin of the femoral triangle.

Lumbosacral trunk:

- Formed by the ventral rami of L4 and L5 spinal nerve.
- Joins the sacral plexus and is distributed via branches of sacral plexus.

Materials: articulated skeleton; prosected specimens: of thorax, superficial and deep abdomen, celiac axis specimen, lateral pelvic walls male and female; **models** of sagittal pelvis, male and female; **radiographs** of abdomen.

TUTORIAL/LABORATORY CLASS 15
THE SUPRARENAL GLAND, KIDNEYS, AND URETER

Aims: To know the structure and function of the kidney, ureter and suprarenal glands, their blood and nerve supply.

Specific Objectives

1. To identify the kidneys and to state their position, and anterior and posterior relations. To identify the hilum of the kidney and its contents.
2. To identify the renal capsule, columns, cortex, medulla, papillae, sinus, major and minor calices of the kidney, and pelvis of the kidney in sections of the kidney.
3. To state the blood, and nerve supply of the kidney and ureter.
4. To identify the ureters, state their major anterior and posterior relations down to the pelvic brim (in abdomen).
5. To interpret radiographs of the kidney and ureter.
6. To identify the suprarenal glands, and state their nerve and blood supply and relationship to the kidneys.

Learning activities

1. With colleagues: (a) identify the **external features** (as listed and described in the lecture notes) of an isolated **kidney** and the **renal vessels**, (b) study the anterior and posterior **relations** of both **kidneys** and those of the **abdominal ureters**, (c) deduce the vertebral level of right and left kidney, (d) identify the **internal features** of the an isolated kidney.
2. Discuss the blood supply to kidney and the effect of an occlusion of a **segmental artery**.
3. Describe the course and relationship of the **ureter** and discuss the effect of an occlusion of the ureter.
4. Identify the **suprarenal gland** and its blood supply.
5. Discuss the role of the **cortex** and the **medulla** of the suprarenal gland.
6. With colleagues, discuss the **nerve supply** to the suprarenal glands.
7. Identify the components of the **kidneys** and **ureters** on radiographs.
1. Examine the **pyelogram** and **cystograms** to see the functional anatomy of the kidney and ureter. Identify features of the urinary tract on plain abdominal radiographs as well as **intravenous** and **retrograde pyelograms**.
8. **Discuss clinical problems 34 and 35.**

Lecture Notes

1. **The Kidneys**

Function: kidneys are paired retroperitoneal organs that produce urine. The **exocrine function:** kidneys are predominantly concerned with maintenance of fluid and electrolyte balance in the body. They are responsible for removal of excess water and waste products of metabolism viz. Salts, toxins and urea from the blood stream. In addition they have **endocrine functions**: production and release of *erythropoietin*, which controls blood cell production, synthesis and release of renin to influence blood pressure; and production of 1,25-hydroxycholecalciferol for control of calcium metabolism.

External features:

- Each kidney is bean-shaped, brownish-red organ, about 11 cm in length, 6 cm wide and 3 cm anteroposteriorly.
- They weigh about 135 to 150 g in the adult and extend from the upper border of the 12th thoracic vertebra down to the 3rd lumbar vertebra.
- The Rt kidney is situated slightly lower than the left due to the presence of liver. Consequently the *transpyloric plane* passes through the superior part of the Rt hilum and the inferior part of the Lt hilum.
- The upper poles of the kidneys are about 6.5 cm apart, the hila 10 cm apart and the lower poles 12.5 cm apart.
- Each **kidney** extends from the upper border of the 12th thoracic vertebra down to the 3rd lumbar vertebra. The Rt kidney is situated slightly lower than the left due to the liver. Consequently the transpyloric plane passes through the superior part of the Rt hilum and the inferior part of the Lt hilum.

Relations of the Kidneys

Posterior: on both sides the posterior relations are the same. Each kidney lies on 4 muscles, 3 nerves, 2 vessels and 1 to 2 bones.

For both kidneys:

Bones: 11th rib, 12th rib (right kidney is lower and hence no 11th rib);

Muscles: Diaphragm, quadratus lumborum, transversus abdominis psoas major

Vessels: subcostal vessels

Nerves: subcostal n. iliohypogastric n., ilioinguinal n.

Left Kidney Anterior (7 Ss):

- spleen
- stomach
- suprarenal gland
- pancreas (sweetbread)
- small intestine,
- Lt colic (**s**plenic) flexure,
- splenic a, and
- splenic v.

Right kidney Anterior:

- Rt suprarenal gland,
- Rt lobe of liver,
- Rt colic flexure,
- small intestine,
- duodenum (related to the hilum)

The Renal Fascia

The kidneys are invested with renal fascia anteriorly and posteriorly. At the lateral borders of each kidney the renal fascial layers fuse; the **anterior layer** passes medially across the kidney to fuse with connective tissue enclosing the aorta and IVC. However, it does not ascend above the superior mesenteric a.

The **posterior layer** passes medially between the kidney and the fascia covering the quadratus lumborum and psoas major, attaching to this fascia at the lateral and medial borders of the psoas major and to the vertebrae and intervertebral discs.

Above the suprarenal gland the two layers fuse and join with the diphragmatic fascia. Below the kidney the two layers are separate and the anterior layer fades into the extraperitoneal tissue of the iliac fossa, while the posterior layer blends with the iliac fascia.

There is a weak septum between the kidneys and suprarenal glands. The renal fascia joins the renal capsule by numerous trabeculae, which traverse the perirenal fat in the perinephric space.

Finally, behind the renal fascia lies a space filled with fat, the pararenal (paranephric body).

Internal features:

- The kidney has a **true** fibrous **capsule** surrounding it, which is composed of collagen-rich tissue with some elastic tissue and smooth muscle.
- In section the kidney shows an internal **medulla** and external **cortex**.
- The medial edge of the kidney shows a longitudinal slit called the **renal hilum**, which leads into the **renal sinus**, containing the **renal pelvis**, renal vessels and fat. In the region of the hilum the renal vein lies anteriorly, the renal artery in the middle and the ureter posteriorly (*water goes under the bridge*).
- The **renal pelvis** is continuous with the **ureter** at the **pelviureteric region**, and receives 2 or 3 **major calices**, which in turn receive **minor calices** (8 to 12).

- The **renal medulla** consists of pale, conical **renal pyramids**. The apices of pyramids (**papillae**) project into the minor calices. Each minor calyx receives 1 to 3 papillae. Each pyramid is capped by cortical tissue to form a **renal lobe**.
- The **renal cortex** arches over the bases of the pyramids and extends between them as the **renal columns**. The peripheral regions of the cortex are known as **cortical arches** and are traversed by radiating, lighter colored **medullary rays**, arising from the medulla. The cortex is generally separated from the medulla by the **arcuate aa** and **vv** although some cortex may lie below this and is known as **subcortex**. The cortex close to the medulla is sometimes known as **juxtamedullary**.

Blood Supply of the Kidney

Renal aa

Originate from the abdominal aorta below the level of the superior mesenteric a. (LV1).

Each renal a. gives off one or more **inferior suprarenal aa** and brr, which supply the perinephric tissue, renal capsule, pelvis and **Ureteric** arteries to supply proximal part of the ureter. Right renal artery is longer, runs posterior to IVC and right renal vein and is crossed by the head of pancreas. Left renal artery arises below SMA, lies deep to left renal vein, body of pancreas and splenic vein.

Accessory renal arteries are common (30% of individuals), usually arising above or below the main renal a. and following it to the hilum. They are common on the left side.

Near the hilum each renal artery divides into **anterior** and **posterior divisions**, which in turn divide into **segmental arteries,** which supply the five so-called renal vascular segments. Each vascular segment is supplied by end-arteries, i.e. no anastomoses between branches. The 5 branches are: **apical**, **superior** (anterior), **inferior**, **middle** (anterior) and **posterior**.

Initial branches of segmental aa are **lobar**, usually one to each pyramid, but before lobar arteries enter the pyramids they subdivide into two or three **interlobar** aa. At the junction of the cortex and medulla, each interlobar a. divides into **arcuate** aa, which diverge at right angles.

Interlobular aa diverge from the arcuate aa to ascend into the cortex, to give rise to **afferent glomerular** aa.

Renal vv

Right and left renal veins drain into the IVC.

The **Lt renal v**. is longer than the Rt and receives the **Lt suprarenal v**., **left inferior phrenic vein** and **Lt gonadal vv.** A few Ureteric veins also drain into left renal vein. Left renal vein crosses to the right renal vein and drains into IVC.

On the Rt side the **right inferior phrenic**, **right renal vein**, **right suprarenal** and **right gonadal veins** drain directly into the IVC.

Nerve supply of the kidney:

Autonomic: The kidney has an extensive nerve supply from **aorticorenal ganglion** and **plexus** and **intermesenteric plexus** as well as from direct sympathetic branches of **lumbar splanchnic nerves**.

The **renal plexus** is formed from branches from the coeliac ganglion and plexus, the aorticorenal ganglion and plexus. The preganglionic sympathetics arise from T10, T11 and T12 via **lesser** and **lowest (thoracic) splanchnic nn., 1st lumbar splanchnic n.** and aortic plexus.

The plexus usually continues into the kidney around the renal aa. Most renal nn are vasomotor. The renal plexus gives rise to the **ureteric** and **gonadal plexuses**.

Afferents: Pain fibres from renal pelvis and upper part of ureter enter the spinal cord by way of the splanchnic nerves. Sensory nn pass back to the CNS with the thoracic splanchnic nn. Pain from kidney is felt in the angle between 12^{th} rib and lateral border of erector spinae.

Lymph drainage of the kidney is into the lumbar nodes.

X-Rays:

The kidney and the ureter can be investigated by: plain X-ray of the abdomen; or Intravenous injection of contrast medium called **intravenous pyelography**; or by introduction of dye into the ureter by retrograde method, called **retrograde pyelography**.

2. **The ureters**

The ureters are muscular tubes, which convey urine from the kidneys to the urinary bladder. Each is about 25 to 30 cm in length and is quite thick walled. Each ureter is divided into three parts: **abdominal**, **pelvic** and **vesical/intramural** parts.

Abdominal part:

- 12.5 cm long and leaves the renal pelvis behind the renal vessels.
- The ureter extends from about the level of LV1, passing over the medial part of the psoas major muscle and the genitofemoral n.
- In PA abdominal X-rays the ureter passes down the tips of the transverse processes of the lumbar vertebrae.
- It is crossed obliquely by the gonadal vessels in its abdominal course and enters the lesser pelvis anterior to either the end of the common iliac or beginning of the external iliac vessels. This point is anterior to the upper limit of the sacroiliac joint as seen in plain PA abdominal X-rays.
- The **Rt ureter** is usually overlapped by the descending part of the duodenum at its origin and is crossed in its abdominal course by the Rt colic and ileocolic aa. Near the superior aperture of the lesser pelvis it passes behind the lower part of the mesentery and terminal ileum.
- The **Lt ureter** is crossed by the Lt colic a., sigmoid colon and root of the sigmoid mesocolon.

Pelvic ureter:

- In the lesser/minor pelvis, the ureter descends on the lateral wall (fascia of obturator internus) along the anterior border of the greater sciatic notch.
- Opposite the ischial spine it turns anteriorly and medially above the levator ani muscle to reach the base of the bladder.
- On the pelvic wall it is anterior to the internal iliac a. and the beginning of its anterior trunk.
- In males the pelvic ureter is crossed by the ductus deferens, after which it lies above the seminal vesicle.
- In females, the ureter lies posterior to the ovary, forming the posterior border of the ovarian fossa.
- As the ureter passes medially towards the bladder it is crossed in females by the uterine a. and lies laterally to the uterine cervix and vaginal fornices.

Vesical or intramural part:

- The ureters terminate in the bladder walls about 5 cm apart, less in the empty bladder.
- As the ureter passes obliquely through the bladder wall it is compressed and flattened as the bladder distends, thus preventing regurgitation of urine.
- Internal Ureteric orifices are 2.5cm apart in an empty bladder and 5cms apart in a distended bladder.

Obstruction to the Ureter:

The narrowest parts of the bladder are at the **pelviureteric region**, where it begins; and along its **intramural course in the bladder**. The ureter is also liable to kinking at the **pelvic brim**. These are likely sites of impaction of ureteric stones.

The blood supply to the ureter

The ureter in its course from renal pelvis to the urinary bladder is supplied from various sources including: the **renal** artery, **abdominal aorta**, **gonadal** arteries, **common iliac**, **internal iliac**, **superior and inferior vesical** and **uterine** aa, depending on the part in question.

There are good longitudinal anastomoses between these vessels.

The venous drainage follows a similar pattern to the arterial supply.

The nerve supply to the ureter

The **autonomic** nerve supply to the Ureter is derived via the **ureteric plexus**. The Ureteric plexus is derived from renal, aortic, superior and inferior hypogastric plexuses.

Sympathetic supply is derived from T10, 11, 12, and L1.

The **parasympathetic** fibres originate from S2 to S4 segments of the spinal cord via pelvic splanchnics. Afferent pain fibres pass back to T11, 12 and L1.

Afferents: Ureteric pain usually due to distension of ureters or obstruction to the ureter. Pain is severe and spasmodic called **renal colic** and travels from loin to groin. It is referred to the labia majora, scrotum and anterior thigh.

In cases of backpressure due to over distension of urinary bladder it can cause dilatation of ureters and or kidneys, a condition called hydroureter and hydonephrosis. The ureter can get retrograde infection from the urinary bladder.

3. **The Suprarenal/Adrenal Glands**

- The suprarenal glands are paired endocrine glands lying anterosuperior to the upper pole of the kidney.
- The suprarenal glands are surrounded by perinephric fat and renal fascia.
- Each gland weighs about 5-10 g in adults.
- Small accessory suprarenal glands (composed of cortical tissue) may be found in the perinephric space adjacent to the main gland or in the spermatic cord, epididymis and broad ligament of the uterus.
- Each gland is made of an outer **adrenal cortex** and inner **medulla**. The cortex is surrounded by a capsule and consists of cords of steroid synthesizing cells (aldosterone, glucocorticoids and sex steroids). The medulla is composed of groups and columns of chromaffin cells, which produce and expel adrenalin and noradrenalin into venous sinusoids.
- Each gland lies on the superomedial aspect of the kidney surrounded by the fatty renal capsule.
- Right gland is roughly pyramidal in shape while left is larger and crescentric in shape.
- The right and left suprarenal glands are separated from each other by crura of the diaphragm, IVC, aorta and coeliac trunk & plexus.

Relationship of suprarenal glands: Several important relations are apparent:

- **Rt suprarenal gland** is posterior to the IVC and Rt lobe of the liver and anterior to the diaphragm and upper pole of the kidney. Its medial border is related to the Rt coeliac ganglion and Rt inferior phrenic a. Laterally the anterior aspect of the gland is in contact with the bare area of liver.
- **Lt suprarenal gland** is posterior to the stomach, spleen, pancreas and splenic a. The medial border is related to the Lt coeliac ganglion, Lt inferior phrenic and gastric aa.

Blood supply of suprarenal gland:

- The suprarenal gland is richly vascular and is supplied by three groups of arteries: **superior, middle** and **inferior** suprarenal arteries. The superior suprarenal artery arises from the inferior phrenic a.; the middle suprarenal artery from the aorta; and the inferior suprarenal artery from the renal a.
- Each gland has a single large **suprarenal v**. The right suprarenal vein drains directly into the IVC, and the left suprarenal vein drains into the Lt renal v.

Lymph drainage is into lumbar (lateral aortic) nodes.

Nerve supply:

Many myelinated preganglionic sympathetic fibres pass through the ganglia of the sympathetic trunk, the coeliac ganglion and plexus, and the aorticorenal ganglion and plexus to synapse in the chromaffin cells of the adrenal medulla. The adrenal medulla is considered as the largest sympathetic ganglion of the body and its stimulation releases adrenaline and noradrenalin hormones in the blood that produce the effects of the sympathetic activity.

Materials: Articulated skeleton; **Prosected specimens** of kidney, deep abdomen, lateral pelvic walls (male and female) **models** of kidneys, lateral pelvic walls male and female, **X-rays**, **torso** model.

WEEK 10

TUTORIAL/LABORATORY CLASS 16

THE URINARY BLADDER AND URETHRA

Aims: To describe the position, external and internal features and peritoneal and visceral relations of the urinary bladder in male and female individuals. To describe the course of urethra in male and female individuals.

Specific Objectives

1. To identify the bladder, its surfaces and immediate visceral relationships.
2. To identify the trigone and the internal urethral orifices.
3. To identify the ligaments, and peritoneal attachments of the bladder.
4. To identify the subdivisions and internal features of the male urethra.
5. To identify the immediate relationships of both male and female urethrae.
6. To describe the nerve supply to the bladder and the neuromuscular basis of micturition.

Learning Activities

1, With colleagues, identify location/position and the gross anatomical features of the **urinary bladder** in male and female.

2. Identify the internal features of the **bladder** and urethra in both sexes. Read the lecture notes and identify the major features of the interior of the urinary bladder.

3. Identify the **ligaments** and **peritoneal reflections** of the urinary bladder in male and female. Identify the **median, medial and lateral umbilical folds** and the structures that raise these folds.

4. Identify the **arterial blood supply**, **venous** and **lymphatic drainage** of the **urinary bladder** and **urethra**.

5. Discuss the **nerve supply** of the bladder. Consider the normal control of bladder function and **micturition**. Discuss the effects of lesions of the spinal cord and sacral nerves on micturition: **automatic**, and **autonomic bladder**.

6. Identify the structure and immediate relationship of the **urethra** in **male** and **female**.

7. To interpret **radiographs** of the bladder. Identify features of the urinary tract on plain abdominal radiographs as well as intravenous and retrograde pyelograms. Examine the **pyelogram** and **cystograms** to see the functional anatomy of the kidney and ureter.

8. **Discuss clinical problem 38.**

Lecture Notes

The Urinary Bladder

This acts as a reservoir for urine and varies in its position and relations according to its state of filling. Bladder capacity in adult males varies from 120 to 320 ml, with micturition usually

occurring at 280 ml. But it can hold approximately 500 ml of urine Values for females are presumably slightly less.

An adult empty bladder lies entirely within the lesser pelvis and is tetrahedral/pyramidal in shape, although shape and size vary with the fullness of bladder. As the bladder fills up with urine, it rises into the abdomen by stripping off the parietal peritoneum that covers it. The urinary bladder in an infant is spindle shaped and is an abdominal organ up to the age of 8 years. As the pelvis of the infant enlarges with age, the urinary bladder descends into the pelvic cavity.

The bladder has four surfaces: **posterior** surface also called the **base** or **fundus**, a **superior surface**, and two **inferolateral surfaces**. It has a **neck** and an **apex,** which is continuous with **urachus** (an the obliterated embryological structure: the allantois) also called the **median umbilical ligament**.

The **superior surface** of urinary bladder is covered by parietal peritoneum, which is reflected on it from the lateral pelvic walls and reaches the anterior abdominal wall. Posteriorly the peritoneum is reflected from the structures that are related to the bladder for example: rectum with the **rectovesical fold,** in males and uterus and cervix with the **uterovesical fold,** in females. Through the peritoneum the superior surface is related to coils of small intestine (ileum) and sigmoid colon in males but in females, posterior part of the superior surface is related to the supravaginal cervix, body and fundus of the uterus across the uterovesical or vesicouterine pouch.

The **base** or **fundus** or the **posterior surface** of bladder is triangular in shape and faces posteroinferiorly towards the rectum. It is related to the anterior wall of vagina in females and in males to the rectum (across the rectovesical pouch), seminal vesicles and ductus deferens. The seminal vesicles and the ampulla of ductus deference are closely applied to the base of the bladder. The rectum is separated from the seminal vesicle and ampulla of ductus deference by a layer of deep pelvic fascia called the **rectovesical septum**.

The **inferolateral surface** is related to **retropubic space**, which is filled with fat and vesical plexus of veins. In males the retropubic space is occupied by **puboprostatic ligaments** (**medial** and **lateral**) and by the **retropubic fat pad**. In females the relations are similar except that the ligg involved are the **pubovesical ligaments** (**medial** and **lateral**).

The **ureters** enter the bladder at the **lateral angles** where the fundus, inferolateral and superior surfaces meet.

The **neck** is the lowest conical part of the bladder and is related to the prostate in the male and the superior fascia of pelvic diaphragm in females. It is pierced by the urethra.

The **bladder wall** consists of an outer adventitial layer of connective tissue, which in some layers has a serosal covering, a muscular layer called the **detrusor muscle** formed by a smooth muscle layer and an inner mucosal layer.

Ligaments of the Bladder

The so-called "ligaments of bladder" are condensation of fibrous tissue extending from the neck of urinary bladder to the walls of pelvis in different directions. These ligaments in both sexes are as follows:

Puboprostatic ligaments: in males ligaments extend from the posterior surface of the pubis to the neck of the bladder. These are sagittal thickenings of pelvic fascia extending from the neck to the posterior surface of the body of pubis. They are in two groups: the medial puboprostatic ligament does not carry anything but the lateral puboprostatic ligament carries superior vesical artery to the bladder.

These are called the **pubovesical ligaments** in females and are the superior extensions of the **pubourethral ligaments**. These are also in two groups: the medial pubovesical ligament does not carry anything but the lateral pubovesical ligament carries superior vesical artery to the bladder.

The puboprostatic and pubovesical ligaments lie on either side of the midline with a small space between them for the transmission of small veins.

Lateral ligaments pass from the neck of the bladder posterolaterally to the lateral walls of the pelvis towards the sacrum. These ligaments carry inferior vesical artery in the male and vaginal artery in female.

The posterior ligaments called the sacrogenital in males and uterosacral in females carry middle rectal artery. These ligaments are covered by a reflection of peritoneal fold called the **sacrogenital fold** (male) or **uterosacral fold** (female).

Both lateral and posterior ligg are regarded as false ligg by some authors.

Fetal Remnants: three fetal remnants are recognized.

Median umbilical ligament: The apex of the bladder is connected to the umbilicus by the **urachus**. It raises the median umbilical fold of peritoneum.

Medial umbilical ligament: Pair of medial umbilical ligaments extends from around the lateral sides of the urinary bladder to reach umbilicus. They contain obliterated umbilical arteries and raise peritoneal folds of the same name.

Interior of the Bladder

Note that the internal surface of bladder is pale and marked with grooves called **rugae**. The rugae are absorbed and vanish when the bladder becomes distended with urine. However, on the internal surface of the base of bladder, there is a smooth area called the **trigone**.

Trigone is always smooth, flat and pink. It is bound: by pair of **internal ureteric orifices** (2.5 cm apart in empty and 5cm apart in full bladder) superiorly and the **internal urethral orifice** inferiorly. The internal ureteric orifices are joined by an **interureteric ridge** or **crest**. Laterally this ridge may extend beyond the ureteric openings as the **ureteric folds**, produced by the ureters running in the bladder wall.

In adult males, particularly past middle age, there is a slight elevation of the mucosa posterior to the internal urethral orifice known as the **uvula**. This is formed by the enlargement of the prostate gland (median lobe).

Blood Supply of the Bladder

Arteries:

i) 2-3 **superior vesical** aa. from the umbilical arteries

ii) In males: **inferior vesical** a. from the internal iliac artery

iii) In females: **vaginal** artery from internal iliac artery

iii) small brr from obturator and inferior gluteal aa.

Veins form a plexus on the inferolateral surface, join **prostatic venous plexus** or vaginal plexus and drain back to the internal iliac v.

Lymphatics: flow to external iliac veins and from lower part to internal iliac nodes or sacral and common iliac nodes.

Nerve Supply of the Bladder:

Micturition reflex: Every reflex arc has an afferent (sensory) and an efferent (motor) limb.

Efferent fibres: *parasympathetic* from the S2 to 4 segments of the spinal cord, the **pelvic splanchnics** or **nervi erigentes**. These enter the inferior hypogastric plexus and pass through it to the bladder wall. They are motor to the detrusor and inhibitory to the internal sphincter. The *sympathetic* are received from the T11, T12, L1 and L2 segments of the spinal cord. They synapse in the inferior hypogastric plexus and postganglionic fibres pass to the bladder. They cause constriction of the internal sphincter and inhibit the detrusor.

Afferent fibres: These are concerned with the awareness of distension and pain. They pass back to the CNS via both the sympathetic and parasympathetic nn.

Normal micturition: Micturition is normally controlled by the parasympathetic system from the level of S2, S3 and S4 and is under the control of higher centres in the brain. Parasympathetic system is motor to detrusor and inhibitory to the internal urethral sphincter. As urine fills the urinary bladder via the internal ureteric orifices, the rugae get absorbed and bladder wall feels the stretch when the volume reaches 200-300 ml. Stretch reflex opens the internal urethral sphincter and the reflex is enhanced further by the descent of urinary bladder on the pelvic diaphragm. Under voluntary control, when the time and place is right one can relax the external urethral sphincter or the sphincter urethrae and urine is voided to the exterior.

Clinical considerations:

Note: the urinary bladder is functionally affected when the individual suffers from spinal cord injuries. Consider the following types of bladder conditions:

Atonic bladder: Atonic bladder is a stage of areflexia and occurs immediately following the injury and occurs due to the setting in of "spinal shock". An acute transection of the spinal cord occurs associated with loss of control of micturition by the higher centres. The patient suffers from retention of urine due to paralysis of detrusor muscle and tonic contraction of internal urethral sphincter. The intravesical pressure rises and finally overcomes the tone of internal urethral sphincter resulting into "overflow incontinence".

Automatic bladder/reflex bladder/infantile bladder: Days or weeks (2-3) following the injury the exact level of injury sets in. In the lesions of spinal cord proximal to the level of S2, the nerve supply of the urinary bladder is not interrupted. Thus the reflex activity of the urinary bladder (S2-S4) is maintained but the central communication of the micturition is interrupted. The bladder fills to its capacity; stretch reflex sets in where the detrusor muscle senses (afferent limb) distension of the bladder; and detrusor muscle contracts and the internal urethral sphincter relaxes (efferent limb). Due to loss of central communication, the patient does not register the urge to pass urine or is not aware of the filling and emptying of bladder and also has no voluntary control over micturition. Patient normally learns to time and automatically evacuate the bladder by applying extravesical pressure in the hypogastric region.

This is also the **infantile bladder**, meaning the bladder of an infant fills to its capacity and automatically empties because the higher centres are not fully developed until the age of 2 years.

Autonomic bladder: Is a type of bladder that is flaccid and occurs when the level of spinal cord injury is below the level of S2-S4 segments. The parasympathetic nerve supply to the bladder is interrupted and there is no central control. The patient suffers from failure of micturition reflex and there also is a loss of desire to micturate. The bladder gets extremely distended with stretching of the detrusor muscle, resulting into retention of urine with overflow and incontinence (urine dribbles). This condition can also be seen in advanced syphilis.

Neurogenic "uninhibited bladder"/ hypertonic bladder: In injuries to the cerebral cortex for example after Cerebrovascular accidents or stroke, depending on the areas of brain affected by the injury the patient may present with various symptoms. For example if the injury may involve the sensory cortex that receives the information of distention of urinary bladder and thus awareness of an urge to pass urine, or may involve the motor cortex that helps to initiate the micturition.

If the motor cortex is involved (corticospinal tracts) the tone of the bladder is greatly increased and since the sensory cortex is undisturbed, the patient feels the distension of bladder, is unable to hold the urine and voids it immediately. The patient also suffers from an uncontrollable desire to micturate and has no voluntary control over micturition.

The Urethra

The Male Urethra

In the male the urethra is 18 to 20 cm long and extends from the internal urethral orifice in the bladder to the external urethral meatus at the expanded end of penis on the glans penis. For

purposes of description the male urethra is divided into four parts depending on its location: **preprostatic**, **prostatic**, **membranous**, and **spongy**.

The **preprostatic part** possesses a stellate or star shaped lumen and is only 1.5 cm long. It extends from the internal urethral orifice to the superior aspect of the prostate. Smooth muscle surrounding the bladder neck and preprostatic urethra is circular and known as the **internal urethral sphincter (sphincter vesicae)**. The sphincter vesicae muscle is richly supplied with sympathetic (T11, T12 and L1) noradrenergic fibres and the parasympathetic nerves (S2-S4) are inhibitory to the sphincter.

The prostatic part is 3 to 4 cm long and extends from the superior aspect of prostate gland and becomes continuous with the membranous part at the inferior aspect of the prostate. It is the widest and most dilatable part and traverses the prostate gland. The lumen of prostatic urethra is crescentric in cross section.

Features on the posterior wall of prostatic urethra: It has a midline longitudinal ridge on its posterior wall known as the **urethral crest**. The crest is broad and prominent at its middle and tapering at its end (almost spindle shaped). The rounded elevation halfway down on the urethral crest, called the **colliculus seminalis** or **verumontanum**. The Colliculus seminalis presents a slit like opening of the **prostatic utricle** on its summit. The prostatic utricle is 6 mm long and is the remnant of the paramesonephric ducts. On either side of the utricle are the openings of the **ejaculatory ducts**. Each ejaculatory duct is 2.5 cm long and is formed by the union of duct of ampulla of ductus deferens and duct of seminal vesicle. Right and left prostatic ducts travel through the prostate gland obliquely and drain in the prostatic urethra. On each side of the urethral crest on the posterior wall of urethra is a groove known as the **prostatic sinus**, which bears 18-20 orifices of the prostatic ducts.

The membranous part is the shortest, about 2 cm in length and the least dilatable part. It passes through the urogenital diaphragm (UGD) and extends from the prostatic urethra to the anterior surface of the bulb of penis to become continuous as the spongy urethra. The part of UGD that surrounds the membranous urethra is called the **external urethral sphincter** or **sphincter urethrae**. Sphincter urethrae is a voluntary sphincter and the striated muscle is supplied by perineal brr of the pudendal n. (S2 to 4). The membranous part of urethra is related to the bulbourethral glands and their duct as well as to the artery of bulb, in the UGD.

The spongy part or the **penile urethra**: begins below the **perineal membrane** or the **inferior fascia of UGD** and is contained within the bulb at the root of penis and within corpus spongiosum in the body of the penis. In its course the spongy urethra is dilated at the beginning as the **intrabulbar fossa**, and again within the glans of the penis as the **navicular fossa**. The ducts of the **bulbourethral glands** open into the spongy urethra below the perineal membrane. The spongy urethra terminates at the external urethral orifice, which is the narrowest part of the urethra. There are several recesses in the spongy urethra known as **lacunae**, which may intercept the point of a cannula, when introduced through the external urethral orifice for diagnostic or therapeutic purposes. Mucous glands known as urethral glands open into the spongy urethra.

External urethral orifice: is a longitudinal slit 6mm long, near the lowest part of glans penis.

The Female Urethra

The female urethra is only 4 cm long, runs forwards and downwards from the neck of bladder to the vestibule of vagina and opens at the external urethral orifice. The external urethral orifice is about 2.5 cm posterior to the glans clitoris and directly anterior to the vaginal opening in the vestibule of vagina.

The **external urethral orifice** is hard to visualize but can be felt as a nodular structure immediately anterior to the anterior wall of vagina. The female urethra has a posterior longitudinal fold also known as the **urethral crest**. The female urethra also has internal and external sphincters.

The Stages of Micturition

- Thoracic diaphragm and anterolateral abdominal wall muscles contract.

- Intraabdominal and intrapelvic pressure increases.
- Pubovaginalis and levator prostatae (pelvic diaphragm) relax.
- Bladder neck drops on the floor causing stretching and an urge to pass urine.
- Downward movement of the bladder initiates contraction of the detrusor and relaxation of the sphincter vesicae (parasympathetic).
- Somatic nerves (s2 to 4) relax the external urethral sphincter (sphincter urethrae).
- Urine passes outwards, and in the female it simply is facilitated by the gravity.
- In the male the rhythmic contractions of the bulbospongiosus muscle surrounding the bulb of penis helps to evacuate the last drops of urine (and semen).
- When micturition ceases the abdominal muscles relax, the levator prostatae and pubovaginalis fibres contract elevating the bladder neck and the sympathetic fibres relax the detrusor and contract the internal sphincter. The external sphincter is also contracted.

Materials: **articulated skeleton**; **Models**: Torso models, models of male and female sagittal pelvis; **Prosected specimens**: deep abdomen and pelvis and isolated bladder, anterior abdominal wall with umbilical ligaments, lateral pelvic walls male and female; **X-rays.**

TUTORIAL/LABORATORY CLASS 17
PELVIS AND PERINEUM

Aims: To describe the bony pelvis and its division into pelvis major and minor. To describe component parts of the floor of pelvis and the disposition of the pelvic fascia. To describe the perineum, boundaries and contents of the superficial and deep perineal spaces.

Specific Objectives

1. To identify, and orientate the hipbones, and name the principal features of the bony pelvis as a whole.
2. To identify the lumbosacral and sacroiliac joints and pubic symphysis, define their articular surfaces and ligaments, and state their functional roles.
3. To state differences between male and female pelvis and the relevance of these to childbearing.
4. To identify the muscles of the walls and floor of the pelvis. State the attachments and actions of the levator ani muscle.
5. To locate the ischiorectal fossa and identify the structures in its walls and floor.
6. To locate the urogenital diaphragm and identify its constituent structures.

Learning activities

1. With colleagues study the **hipbones**, **sacrum** and **coccyx** and name the principle features of these bones.
2. Identify the **lumbosacral, iliolumbar and sacroiliac joints** and the **pubic symphysis**. Identify their articular surfaces, capsule and ligaments. Define their functional roles.
3. Identify the **bony pelvis**, **pelvic inlet and outlet**, and understand the role of pelvic diameters in females.
4. Identify the muscles of the walls: **piriformis, iliacus, and obturator internus** and floor of pelvis: the **pelvic diaphragm** that is contributed by a pair of **levator ani** and pair of **coccygeus** muscles. Describe the pelvic diaphragm. State the attachments and actions of the levator ani muscle.
5. Deduce the planes of engagement and rotation of the fetal head during its movement down the birth canal. Discuss factors responsible for rotation and flexion of the fetal head during parturition.
6. Locate the **ischiorectal fossa**, its boundaries, recesses, walls, floor and contents.
7. With colleagues and your tutor discuss the clinical importance of the **pudendal canal**.

8. Define the **perineum**. Identify the **superficial and deep perineal spaces**, the **urogenoital diaphragm**, and **perineal body**.
9. Identify the urogenital diaphragm and state its constituent structures in male and female.
10. Identify the following branches of the **internal iliac artery**: **iliolumbar, lateral sacral, superior and inferior gluteal, internal pudendal, umbilical and obturator**.
11. With colleagues note the features of the bony pelvis on radiographs.
12. **Discuss clinical problem 37.**

Lecture Notes

A) Bones, Joints and Ligaments of the Pelvis

Bones of the pelvis:

The pelvis is made by the two hipbones (appendicular skeleton) and the sacrum and coccyx (axial skeleton). It has a **pelvic inlet**, a **pelvic cavity** and a **pelvic outlet**. The pelvis is divisible into **pelvis major** or the **false pelvis** and a **pelvis minor** or **true pelvis**.

The **minor/lesser/true pelvis** extends from the **superior pelvic aperture** or the **pelvic inlet** to the **inferior pelvic aperture** or **pelvic outlet**. The pelvic inlet is tilted at an angle of 50 to 60^{o} to the horizontal, and its axis generally passes through the umbilicus and the coccyx.

The **superior pelvic aperture** or **pelvic inlet** is called the **linea terminalis** and is bound by: sacral promontory, ala of sacrum, arcuate line of ilium, pecten pubis, pubic crest & pubic symphysis.

The **inferior pelvic aperture** is bound by the coccyx, sacrotuberous ligament, ischial tuberosity, ischiopubic ramus and pubic symphysis. The pelvic outlet is tilted at 15^{o} to the horizontal and the axis of the inferior pelvic aperture passes through the sacral promontory.

Revise the following important features of the bones of the pelvis. This should be revision from work done in Introductory Anatomy.

i) **Ilium**: **iliac crest, gluteal surface, iliac fossa, anterior superior iliac spine, anterior inferior iliac spine, posterior superior iliac spine, posterior inferior iliac spine, tubercle of the iliac crest, greater sciatic notch, arcuate line, iliopubic (iliopectineal) eminence, auricular surface, iliac tuberosity**.

ii) **Pubis**: **pubic symphysis, pubic body, pubic crest, pubic tubercle, superior and inferior pubic rami, obturator crest, pectineal line (pecten pubis), obturator groove, obturator foramen**.

iii) **Ischium**: **ischial tuberosity, ischial spine, lesser sciatic notch, ischiopubic ramus, acetabular notch, acetabular fossa, non articular and articular (lunate surface)**.

iv) **Sacrum**: **sacral promontory, superior articular facets, ala, auricular surface, pelvic and dorsal sacral foramina, sacral hiatus, median sacral crest, intermediate sacral crest, lateral sacral crest, inferior sacral cornua**.

Joints and Ligaments of the Pelvis

Sacroiliac joint:

- Synovial joint between the auricular surfaces of the ilium and sacrum. The joint surfaces are irregular in adults. Several ligaments are associated with the joint.
    - **ventral sacroiliac**, an anterior capsular thickening.
    - **interosseus sacroiliac**, actually a syndesmosis, extending from the sacrum posterior to the auricular surface to the iliac tuberosity. It is overlaid by the dorsal sacroiliac ligament.
    - **dorsal sacroiliac ligament**.

Pubis symphysis:

- Pubic bones meet in the midline at the fibrocartilaginous pubic symphysis and are connected above and below by **superior pubic** and **inferior (arcuate) pubic ligaments**. The bone surfaces are covered by hyaline cartilage, which is in turn joined to the opposite side by fibrocartilage.

Sacrococcygeal joint: contains a fibrocartilaginous disc.

Lumbosacral joint:

- This is between the 5th lumbar and 1st sacral vertebra. Their bodies are united by a symphysis including a large intervertebral disc, with anterior and posterior longitudinal ligaments. The **iliolumbar ligament** extends from the tip of the 5th lumbar transverse process to the sacrum (blending with the ventral sacroiliac ligament) and the iliac crest.

Vertebropelvic ligaments:

- The sacrum is connected to the ischium by **sacrotuberous** and **sacrospinous ligaments**. They also convert the sciatic notches into respective foramina. The sacrotuberous lig. extends from the posterior and lateral margins of the sacrum and coccyx to the ischial tuberosity. The sacrospinous lig. extends from the ischial spine to the lateral margins of the sacrum and coccyx anterior to the sacrotuberous ligament with which it fuses. Its anterior surface is muscular and constitutes the **coccygeus (ischiococcygeus) muscle**; the ligament often being regarded as a degenerate muscle. The **iliolumbar ligament** connects the LV5 transverse processes with the iliac crest.

Diameters and Types of Female Pelves

The female pelvis differs from the male in several features. These are a consequence of the role of the female pelvis in parturition.

- the subpubic angle is 50 to 60^{o} in males and 80 to 85^{o} in females.
- females have broader alae than males.
- the pubic bone is relatively wider in females, with greater relative separation of the pubic tubercles.
- roughened areas on bones for muscle attachments are much less obvious in females.
- the auricular surfaces are smaller in females.

Several important diameters of the pelvis in females may be noted:

i) **superior pelvic aperture**

- anteroposterior diameter (true conjugate) - from the sacral promontory to the superior border of the pubic symphysis (11.2 cm).
- transverse diameter - maximum transverse diameter of inlet (13.1 cm).
- oblique diameter - from iliopubic eminence to opposite sacroiliac joint (12.5 cm).

ii) **lesser pelvic cavity**

- anteroposterior diameter - 3rd sacral segment to midpoint of posterior aspect of the pubic symphysis (13.0 cm).
- transverse diameter - maximum transverse diameter (12.5 cm).
- oblique diameter - lowest point of one sacroiliac joint to midpoint of opposite obturator membrane (13.1 cm).

iii) **inferior pelvic aperture**

- anteroposterior diameter - from the coccygeal apex to the midline lower point of the pubic symphysis (12.5 cm).
- transverse diameter - between the ischial tuberosities (11.8 cm).

- oblique diameter - from the midpoint of sacrotuberous lig. to the contralateral ischiopubic junction (11.8 cm).

Note:

The diagonal (oblique) conjugate is the only diameter, which may be measured *per vaginam* and is the distance from the sacral promontory to the lower symphyseal border (12.5 cm).

The birth canal:

The birth canal is the path followed by the fetal head in its course through the pelvic cavity. Initially the birth canal is at right angles to the plane of the pelvic inlet, extending to the level of the ischial spines, at which point the canal turns at right angles to its original course to pass down the vagina and emerge below the pubic symphysis.

As the fetal head descends through the birth canal, the fetal suboccipitobregmatic diameter successively occupies i) the transverse diameter of the inlet, ii) the oblique diameter of the cavity and iii) the anteroposterior diameter of the outlet.

Types of pelves in Caucasian females:

- gynaecoid, round with enlarged transverse diameter (41.4%)
- android, heart shaped (32.5%)
- anthropoid, long AP diameter (23.5%)
- platypelloid, long transverse diameter (2.6%)

Muscles of the Pelvis

Pelvic muscles form two groups:

i) Muscles of the lateral wall: The **piriformis** and **obturator internus** form the lateral wall of the pelvis and they are only significant for us in that they form a background for pelvic contents.

ii) The muscle of the floor: The **pelvic diaphragm**, is made of a pair of **levator ani** and a pair of **coccygeus muscles**.

Pelvic diaphragm:

The Levator Ani Muscle

The levator ani muscle of the right and left side together form a funnel shaped floor of the pelvis. The levator ani is attached anteriorly to the pelvic surface of the body of pubis and posteriorly to the Ischial spine. In between these two bony points the muscle attaches to the thickening of the obturator fascia called the **tendinous arc (arcus tendineus).**

The right and left levator ani muscles converge downwards on the midline viscera e.g. urethra and anal canal in male and urethra, vagina and anal canal in female, and support them.

They are also attached medially, from anterior to posterior, into the **perineal body** or the **central tendon of perineum, anococcygeal raphe** or **ligament** and the coccyx. The anococcygel ligament is attached to the anorectal flexure anteriorly and to the tip of coccyx posteriorly.

The levator ani is covered above by the superior fascia of the pelvic diaphragm and below by the inferior fascia of the pelvic diaphragm. Below the inferior fascia of the pelvic diaphragm lies the **ischiorectal fossa** (see below).

The levator ani muscle consists of **three** parts: **pubococcygeus, iliococcygeus and puborectalis muscles**.

i) **Pubococcygeus**

The pubococcygeus muscle forms the bulk of levator ani. This muscle extends from the posterior surface of the pubis and anterior part of the tendinous arc (fascia covering the obturator internus), anococcygeal ligament and the coccyx.

The pubococcygeus has following component muscles:

- **Levator prostatae** in the male and **pubovaginalis** in the female. These muscles insert into the neck of the bladder and are important in elevating the bladder neck and thus the control of micturition.

- The **levator prostatae** are the anterior fibres of pubococcygeus in male that insert into the prostate gland.
- The anterior fibres of pubococcygeus in female insert around vagina and uretha and are called the **sphincter vaginae** also acts as a vaginal sphincter.
- The remaining fibres of pubococcygeus insert into perineal body, anoccygeal raphe and the coccyx.

ii) **Iliococcygeus**

This muscle extends from the posterior part of the tendinous arch of levator ani (the thickening of the obturator internus fascia) and the ischial spine to insert into the side of the coccyx and the anococcygeal lig.

iii) **Puborectalis**

This muscle is in the form of a sling, which lies at the lowest level of the funnel, below the other two muscles. It is attached anteriorly to the back of pubis, passes backwards to encircle the anorectal junction and meets with the fellow of the opposite side. Normally the puborectalis is not anchored posteriorly to any bony or fibrous tissue and thus the muscle sling with its normal tone keeps the anorectal junction at right angles and hence has to be voluntarily relaxed for passage of stools during defecation. Although some authors believe that the posterior fibres of puborectalis mingle with those of the external anal sphincter or merge with the anococcygeal ligament.

Coccygeus muscle:

Is a triangular muscle and arises from the ischeal spine to attach medially to the last piece of sacrum and the coccyx. On its external surface it blends with the sacrococcygeal ligament and it is believed that the sacrococcygeal ligament is the external degenerated part of the coccygeus muscle. Coccygeus forms the posterior part of the pelvic diaphragm.

Functions of the pelvic diaphragm:

The various parts of levator ani muscles act together with the coccygeus to:

- support the pelvic viscera
- opposing and/or controlling and/or augmenting increased intraabdominal pressure in several functions eg. parturition, micturition, defecation.

Perineum:

Perineum is the region of trunk that lies below the pelvic diaphragm and is the pelvic outlet, which when viewed from below resembles a diamond shape.

Pelvic outlet, Urogenital Diaphragm and Ischiorectal Fossa

The inferior aperture of the pelvis, the **pelvic outlet**, is bound anteriorly by the pubic symphysis, laterally by the ischiopubic rami, the ischial tuberosities and sacrotuberous ligaments, and posteriorly by the lower part of sacrum and coccyx bones.

It is divided into a **urogenital triangle** anteriorly and an **anal triangle** posteriorly by an imaginary line that connects the two ischeal tuberosities. The midpoint of this transverse line is the centre point of perineum called the **perineal body** and is formed by the tendinous attachments of nine muscles of the perineum. The perineal body lies in between the urogenital orifices anteriorly and anal orifice posteriorly.

The **urogenital triangle** is bridged by the **urogenital diaphragm (UGD),** which comprises muscles and associated fascia. The UGD is covered superiorly by the superior fascia of UGD and inferiorly by the inferior fascia of UGD. The superior fascia of the urogenital diaphragm is separated from the inferior fascia of the pelvic diaphragm by the **anterior recess of the ischiorectal fossa**. The inferior fascia of UGD is also called the **perineal membrane**.

Urogenital diaphragm:

Is a triangular sheet of skeletal muscle consisting of three muscles. Identify the anterior part: the **sphincter urethrae** muscle (external urethral sphincter) and the posterior part: a pair of **deep transversus perinei** muscles.

Sphincter urethrae forms the bulk of UGD and arises from the internal surface of the inferior ramus of pubis, fibres running in circular fashion around the membranous urethra in male and urethra and vagina in female. In female sphincter urethrae also acts as sphincter vaginae. In male the sphincter urethrae constricts and evacuates the last drops of urine or semen at the end of micturition and ejaculation.

Deep transversus perinei: pair of narrow transverse slips of muscle that attach laterally to the ischial ramus and insert medially into the perineal body.

Enveloped between the layers of fascia in the perineum are the spaces called **deep** and **superficial perineal spaces**. Examine from the inside the pelvic cavity and travel inferiorly towards the skin of the perineum and identify the fascia and contents of the deep and superficial perineal spaces.

Deep perineal space or pouch: The deep perineal space lies between the superior and inferior fascia of the urogenital diaphragm. The fasciae are attached laterally to the pubic arch and blend with each other anteriorly and posteriorly.

Contents of the deep perineal space include: sphincter urethrae, pair of deep transversus perinei muscles (urogenital diaphragm); membranous urethra and Bulbourethral gland & duct; and arteries and nerves of penis in male. In the female the deep perineal space contains UGD; urethra and vagina; and arteries and nerves of clitoris.

Superficial perineal space or pouch:

The superficial perineal space lies inferior to the inferior fascia of the UG diaphragm or the **perineal membrane**, and superior to the membranous layer of the **superficial fascia of the perineum (**Colle's fascia).

Contents of the superficial perineal space include: erectile tissues structures that form the root of penis (bulb of penis and pair of crus of penis) or clitoris (bulb of vestibule and crus of clitoris; the muscles surrounding these erectile tissues (bulbospongiosus and ischiocavernosii) and the neurovascular structures. The muscles of the superficial perineal space on each side are: **superficial transversus perinei, bulbospongiosus** and **ischiocavernosus muscles**. In female the deep perineal space also contains the greater vestibular glands.

The **superficial transversus perinei** pass medially from the ischial tuberosity to the **tendinous centre of the perineum or perineal body** located between the vagina and anus in the female, and between the membranous urethra and anus in the male.

The **ischiocavernosus** muscle covers the crura of the penis or clitoris, while the **bulbospongiosus** covers the bulb of the vestibule (female) or bulb of the penis (male).

The **perineal body** or central tendon of perineum is a fibromuscular body that lies in the midline in between the urogenital and anal triangles. It is a very important structure as it gives attachment to nine muscles of the perineum. It receives fibres from the levator prostatae and pubovaginalis (pair of levator ani); pair each of deep and superficial transversus perinei; sphincter ani externus, and (a pair) bulbospongiosus. In female, when it is damaged during childbirth or perineal tears, the muscular support of pelvic viscera is weakened and this may lead to prolapse of urinary bladder, uterus, cervix and rectum through the pelvic floor.

Ischiorectal fossa: The wedge shaped potential space below the pelvic diaphragm and on either side of the anal canal is known as the **ischiorectal fossa**.

This space is bound *laterally* by the sacrotuberous ligament, ischiopubic ramus and fascia over the obturator internus muscle. Its *roof* is formed by inferior fascia of the pelvic diaphragm. *Medially* it is related to the anal canal and the external anal sphincter. *Anteriorly* the space extends between the levator ani and UG diaphragm as the **anterior recess** of the **ischiorectal fossa** and *posteriorly* the space extends deep to the gluteus maximus muscle and is called the **posterior recess** of **ischiorectal fossa**.

The space is filled with fat, which is fluid at body temperature and allows the dilation of the anal canal as faeces passes through. The ischiorectal fossa also contains the inferior rectal vessels, inferior rectal nn, br. of the posterior femoral cutaneous n. and perforating cutaneous nn.

Pudendal canal: In the lateral wall of the ischiorectal fossa the inferior fascia over the obturator internus is reflected and split (lunate fascia) to form a tunnel known as the **pudendal canal**, which transmits the internal pudendal a. and v., and the pudendal n.

Materials: **articulated skeleton,** bony pelvis, hip bones, sacrum, pelvis with ligaments**; models:** torso, pelvis rubber model, pelvis model (new!), male and female sagittal pelvis models; **prosected specimens:** of the abdomen and pelvis, posterior abdominal wall specimen, lateral pelvic wall specimen; **X-rays:** radiographs visceral, pelvis.

APPENDIX 4
Used for Laboratory Class 22
SURFACE ANATOMY OF ABDOMEN AND PELVIS

Instructions: the surface/palpatory/living anatomy of the abdomen and pelvis should be read by the student and incorporated in the study of organs and structures of various systems.

ABDOMINAL WALLS AND ABDOMINAL CONTENT

1. The anterior abdominal wall is bound superiorly by: the xiphoid process and costal cartilages of the 7th to 10th ribs. Inferiorly on each side it is bound by: the iliac crest, anterior superior iliac spine, the inguinal ligament and pubic crest and symphysis.
2. Note the position of the umbilicus - usually it lies at the level of the disc between the 3rd and 4th lumbar vertebra. Linea alba is indicated by a slight groove in the anterior median line, which extends from the xiphoid process to the symphysis pubis. The lineae semilunares are slight surface depressions, which indicate the lateral borders of rectus abdominis muscles. To identify the semilunar lines, lie on your back and then sit up without using your arms. This contracts your rectus abdominis muscles making their lateral margins stand out. These lines extend from the pubic tubercles to the costal margins at the tip of nine costal cartilages. The lineae transversae are grooves overlying the tendinous intersections of the rectus abdominis.
3. Planes and points of reference: For clinical purposes the anterolateral abdominal wall is divided into nine abdominal regions by two vertical (midclavicular) planes and by two horizontal (transpyloric and transtubercular) planes. The transpyloric plane is situated midway between the xipisternal joint and the umbilicus, at the level of the intervertebral disc between LV1 and LV2 and the 9th costal cartilage (it usually passes through the pylorus of the stomach, hence its name. The transtubercular plane passes through the iliac tubercles and lies at the level of the body of LV5. Additionally there are: the subcostal plane which joins the lowest points of the costal margins on each side and lies at the level of the intervertebral disc between LV2 and LV3, and the transumbilical plane which passes through the umbilicus. In clinical practice it is used, together with the median plane, to divide the abdominal wall into four quadrants.
4. Palpate on the abdomen: Anterior superior iliac spine, iliac crest, iliac tubercle (the highest point of the crest is at the level of LV4) posterior superior iliac spine (in the visible dimple at the level of the 2nd sacral vertebral spine), pubic tubercle and crest, inguinal ligament (if palpable).
5. Large Abdominal Vessels (mark them with a pencil):
   Abdominal Aorta: enters the abdomen at the disc between TV12 and LV1 (above the transpyloric plane), descends on the bodies of LV1-4 and bifurcates into the common iliac arteries in front of LV4, i.e. slightly below the umbilicus. In a thin individual who is nicely relaxed, the pulsation may be felt quite easily when abdominal wall is relaxed by flexing the thigh and the legs.
   Common and external iliac arteries: may be mapped out by drawing a line between ASIS and symphysis.
   Inferior Vena Cava: is 2 to 3 cm wide, lies to the right of the aorta. It arises in front of the body of LV5 (transtubercular plane) and ascends to the level of TV8.
6. Abdominal Viscera
   Stomach: The surface features of the stomach vary greatly because its size and position change under a variety of circumstances. The cardiac orifice of the stomach is located posterior to the 7th left costal cartilage, about 3 cm from the midline, at the level of the 10th or 11th TV. The fundus of the stomach corresponds to the left dome of the diaphragm. The highest point of the

fundus is located posterior to the 5th left rib in the midclavicular line. The greater curvature is usually between the transpyloric and transtubercular planes. The pyloric part of stomach is usually between transpyloric and supracristal (a horizontal plane between the highest points of the iliac crest) planes, about 2 to 3cm to the right. In the erect position, the location of the pylorus varies from about the level of the LV2 to the level of LV4; in the supine position from LV1 to the LV3.

Duodenum: draw the superior part of the duodenum superiorly and laterally to the pylorus, the descending part opposite LV1-3 and medial to the midclavicular plane; horizontal part across the midline for about 8 cm; and ascending part at the level of LV2, lateral to the aorta.

Ascending colon: begins at the transtubercular plane lateral to the midclavicular plane and ascends to the area just below the transpyloric plane. Note that it overlies the lower part of the right kidney.

Descending colon: descends from the level of the 11th rib (lower border of the spleen) lateral to the midclavicular plane.

Transverse colon: this forms a loop of variable depth between the right and left colic flexures. Mark it below the horizontal part of duodenum.

Spleen: is located deep to the 9th, 10th and 11th left ribs. Normally the spleen does not extend below the left costal margin and its anterior tip does not extend farther anteriorly than the midaxillary line. It is usually not palpable unless it is enlarged or is markedly dislocated.

Pancreas: is located in epigastric and left hypochondriac regions. It lies across the bodies of the upper lumbar vertebrae with its head below the transpyloric line and its tail slightly above it. The tail rests on the lower part of the visceral surface of the spleen. The splenic artery runs along its upper border to the left, the hepatic artery runs along its upper border to the right.

Liver: At the right midaxillary line it lies opposite the 7th - 11th ribs; at the midclavicular line it ascends to the level just below the right nipple (5th rib), then it curves to the left reaching again the level of the 5th rib in the left midclavicular line. It is depressed by the heart in the median plane to the level of the xiphisternal junction. Its sharp lower border crosses the pylorus and the fundus of the gall bladder in the transpyloric plane. The inferior margin of the normal liver is usually not palpable.

Gallbladder: Mark the fundus as a pouch projecting downwards from the angle between the right costal margin and the lateral edge of the right rectus abdominis muscle.

Kidneys: The levels of the kidneys change during respiration and with changes in posture. Each kidney moves about 3cm in a vertical direction during full movement of the diaphragm. The hila of the kidneys lie close to the transpyloric plane and about 5cm away from the median line. The upper pole of the kidneys is opposite the 12th rib and the 12th TV, whereas the lower pole is opposite the 3rd LV, and about 2cm above the iliac crest. (Note that the right kidney is a little lower than the left kidney).

Urinary Bladder: When the bladder is empty, the parietal peritoneum passes from the anterior abdominal wall onto the back of the symphysis. When the bladder is filled, the loose peritoneum is lifted off the abdominal wall some distance above the symphysis. As the bladder fills, it gradually rises into the abdomen proper and it may reach the level of the umbilicus. At birth, the bladder lies in the abdomen proper. During childhood it gradually sinks to the position noted in the adult.

WEEK 11

TUTORIAL/LABORATORY CLASS 18

FEMALE REPRODUCTIVE SYSTEM

Aims: To describe the internal and external organs and structures of the female reproductive system, their blood and nerve supply and lymphatic drainage.

Specific Objectives

1. To identify the ovaries, uterine tubes, uterus and broad ligament.
2. To state the peritoneal relationships of the ovary and uterine tube.
3. To identify the component parts of the uterine tube.

4. To identify the components parts of the uterus. State the position of the uterus and define the terms anteversion and anteflexion.
5. To describe the peritoneal relationships of the uterus and vagina and identify the immediate visceral relationships of the uterus.
6. To identify the walls, fornix and the immediate visceral relations of the vagina.
7. To describe the supports of the uterus.
8. To identify the female external genitalia.
9. To describe the blood supply and lymph drainage of the female genital tract.
10. To summarize the nerve supply to the ovary, uterus and vagina.
11. **Discuss clinical problems 39, 40 and 41.**

Learning activities

1. Identify the **ovaries** and the ligaments of ovary. Identify the **ovarian ligament** and the **suspensory ligament**. Discuss the blood and nerve supply and the venous and lymphatic drainage of the ovary. Identify the **ovarian artery** and right and left **ovarian veins**. Identify **inferior hypogastric plexus** and **pelvic splanchnic nerves**.
2. Identify the **uterine tube** and its parts: intramural, **isthmus, ampulla, infundibulum** and **fimbria**. Discuss the blood and nerve supply and the venous and lymphatic drainage of the uterine tubes.
3. Identify the **uterus**, and its parts: **fundus, body, cervix**.
4. With colleagues, identify the relationship of the uterus to the bladder and rectum and its position in the lesser pelvis. Discuss the anteversion and anteflexion of the uterus. Discuss the arrangement of uterine musculature and the significance of this arrangement in parturition.
5. Identify the **ligaments** and supports of the uterus and cervix. Identify the **broad ligament** and its three constituent parts: **mesometrium, mesosalpinx, mesovarium**. The mesometrium contains the **uterine A**. and **V**., **ovarian ligament**, **round ligament of uterus** and uterovaginal plexus of nerves, embedded in loose connective tissue (parametrium). Identify the **uterosacral ligaments** and the **uterosacral folds**, which they raise. Identify the **Transverse (lateral) cervical ligaments** also called the **cardinal ligament** and note that it extends from the side of the cervix to the upper fascia of the pelvic diaphragm. *What are the contents of the transverse cervical ligament?*
6. On the models and prosected specimens of pelvis and abdomen identify the components of the **external genitalia** in female and relations of the vagina. Identify: **mons pubis**, **pudendal cleft, labia majora and minora**, anterior commissure, **vestibule of the vagina**, **bulb of the vestibule**, **greater vestibular gland**, **frenulum** and **prepuce of the clitoris**, glans of the clitoris, carunculae hymenales (if visible).
7. Identify the arteries, which supply ovary, uterine tube, uterus and vagina. Identify **ovarian artery, uterine artery** and the **vaginal** artery in prosected specimens of pelvis.
8. Discuss venous and lymphatic drainage of these organs.
9. **Radiographs:** Identify the **cavity of the uterus**, and parts of the **uterine tube** on the hysterosalpingogram. Note: commonest cause of infertility is blockage of the uterine tube. Patency of the uterine tube may be tested by filling the uterine cavity with a contrast medium and observing by X-ray the spillage of the material into the peritoneal cavity. Patency can also be seen laparoscopically by passing radiolucent CO2 into the tube.

Lecture Notes

Female reproductive system consists of:

1. **Ovary:**

   Ovary is the female gonad that is responsible for the production of ova after puberty and secretion of estrogen and progesterone hormones. In the prepubertal female each **ovary** is a solid pinkish

white gland about the size and shape of an almond. The surface of ovary is smooth until puberty. After puberty however, the surface of ovary generally gets puckered by the monthly scars of ovulation.

Ovarian fossa: Each ovary lies in the **ovarian fossa**. The ovarian fossa is a peritoneal depression immediately below the pelvic brim. Ovarian fossa is bound *anteriorly* by the **obliterated umbilical artery**, and *posteriorly* by the ureter and the internal iliac a. *Lateral wall* of the ovarian fossa is covered by peritoneum deep to which lies the obturator nerve and vessels. Note: that the diseases of the ovary may irritate the underlying nerve and cause referred pain radiating down to the knee.

The ovary has two surfaces: **lateral** and **medial**; two ends: **tubal** and **uterine**; and two borders: **anterior** or **mesovarian** and **posterior** or **free**. The medial surface is related to coils of small intestine and sigmoid colon through the peritoneal cavity.

The tubal end of the ovary is surrounded by the **ovarian fimbria of the uterine tube** and is attached to the **suspensory ligament of the ovary**. The suspensory ligament contains the **ovarian artery and vein**.

The uterine end faces the pelvic floor and is attached to the side of the uterine body by the **ovarian ligament,** which lies in the broad ligament of the uterus.

Blood supply and venous & lymphatic drainage

Arterial supply: The **ovarian artery** is a branch of the abdominal aorta at the level of L2 and it enters ovary through the mesovarium. It is coiled near the ovary to allow movement of the ovary during pregnancy. Ovary also receives blood supply via the **tubal branch of uterine artery**, supplying medial one third of the ovary. Ovarian artery in addition to supplying the ovary also gives off a **tubal branch** that supplies lateral one third of the uterine tube.

Venous drainage: the veins from the ovary form a **pampiniform plexus**, that gives rise to a single **ovarian vein** as it travels over the psoas fascia. The ovarian vein runs alongside the ovarian artery. The right ovarian vein enters **IVC** and the left ovarian vein enters the **left renal vein.**

Lymphatic drainage: the lymphatics are conveyed to the lumbar lymph nodes.

Nerve supply: The ovaries are supplied by sympathetic nerves from the level of T11 and T12 segments of the spinal cord.

Afferents: Pain of the ovary is referred to the inguinal and vulval regions and may be confused with pain from the ureter.

2. **Uterine tubes:** There are two uterine tubes.

Each **uterine tube** is 10-12 cm long and extends from the ovary to the upper angles or the cornua of the uterus.

It has 4 parts: (from lateral to medial) **infundibulum**, **ampulla**, **isthmus** and **intramural**.

The **ampulla** is the widest part, where the fertilization of the ovum takes place and the fertilized ovum continues to stay in the ampulla for about five days. The **isthmus** is the smallest and thinnest part and continues as the **intramural** part that passes through the musculature of the uterus. The **infundibulum** is trumpet shaped and presents an opening called the **abdominal ostium** of the uterine tube. The edge of the infundibulum is rimmed by irregular finger like projections called the **fimbriae**, one of which is longer than the others and is called the **ovarian fimbria**.

Abdominal ostium opens directly into the peritoneal cavity and infections of the uterine tube may spread into the peritoneal cavity via this route. Pelvic peritonitis may occur under poor hygienic conditions especially in younger females with vulvo-vaginitis.

Ectopic pregnancy: fertilised ova may implant in the tube. Ampulla is the most common site of ectopic pregnancy. Ectopic embryo may abort into the peritoneal cavity or enlarge and rupture the uterine tube

Salpingitis: is inflammation of the tube, (salpinx = trumpet). Pain is felt in the lower abdomen

Uterine tubes are tied for birth control and the procedure is called tubectomy.

Blood supply. Branches of the **ovarian** and **uterine** arteries form an **arterial arcade** under the uterine tube, within the broad ligament. Right ovarian vein drains into IVC and the left ovarian vein drains into left renal vein. The uterine veins drain into internal iliac veins.

Lymph flows to paraortic (lumbar) nodes after linking with those of the ovary. Some drain into internal iliac nodes or along the round ligament to the superficial inguinal nodes.

3. The **uterus**:

Uterus is the organ of gestation and is pear shaped hollow organ that is flattened anteroposteriorly. A non-pregnant uterus is approximately 7.5 cm long, 5 cm wide and 2.5 cm thick and weighs approximately 40 g.

It lies between the bladder *anteriorly* (related across the **vesicouterine pouch**) and the rectum *posteriorly* (related across the **rectouterine pouch**). It is covered on parts of its posterior (**intestinal**) and anterior (**vesical**) surfaces by peritoneum.

The uterus has an expanded part called the **body**, with anterior and posterior surfaces and lateral margins, receiving the attachments of the **round ligament of the uterus** and **ovarian ligament.**

It has a **fundus**, the part of uterus that protrudes above the attachments of the **uterine tubes**.

The **isthmus**, is the narrow part of the uterus that is lower uterine segment and is visible as a groove between the body and cervix of uterus.

The **cervix** meets the vagina at right angles and enters into the anterior vaginal wall, thus dividing the cervix into **supravaginal** and **vaginal parts**.

Discuss the relationships of the supravaginal part of the cervix. Note that the supravaginal part of cervix is separated from the urinary bladder anteriorly and inferiorly by loose connective tissue. It lies behind the uterovesical pouch. It opens into the cavity of the uterus by the **internal os**. It is related laterally to the **ureters** and the **uterine arteries**.

The cavity of the cervix is called **cervical canal** and is fusiform in shape and internally has **palmate** folds in the mucosa radiating as longitudinal folds on the anterior and posterior walls. In pregnancy the cervical canal is filled with a mucus plug. The cervical canal communicates with the vagina via an **external ostium (external os)**, and the cavity of the uterine body by an **internal ostium (internal os)**. The vaginal part of cervix, due to genetic or chronic inflammatory causes is prone for cancers of the cervix and this accounts for 10% of fatal cancers in women.

The cervix is attached to the walls of the pelvic cavity by thickenings of the pelvic fascia that are called ligaments and, which help to anchor the uterus. The **transverse cervical** and the **uterosacral ligaments** are the main ligaments that can be identified (see below)**.**

Orientation.

Angle of anteversion: In the normal anatomical position the long axis of the cervix forms an angle of **90 degrees** with the vagina; i.e. the uterus is bent forward on the vagina at a right angle.

Angle of anteflexion: The long axis of the uterine cavity forms an angle of **170 degrees** with the long axis of the cervical canal; and thus the body of the uterus is also bent forward on the cervix at the isthmus.

Retroflexion: is the abnormal orientation of the body, when it is bent backward on the cervix

Retroversion: is also an abnormal orientation, where the cervix is bent backward on the vagina.

Note: If the uterus lies in a neutral position (neither anteverted nor anteflexed) i.e.: in the same axis as the vagina, intrabdominal pressure will tend to push it down the vagina and it may exit from the vagina leading to the **prolapse**.

Blood & nerve supply and venous & lymphatic drainage

Arteries: right and left **uterine arteries**. Uterine arteries one on each side is a branch of the anterior division of internal iliac artery and they reach the lateral wall of uterus traveling at the lower limit of broad ligament in the transverse cervical or the cardinal ligaments. The uterine arteries cross ureter anteriorly about 2 cm from the cervix and run a tortuous course within the broad ligament along the lateral side of the uterus.

Veins. Uterine veins drain into internal iliac veins.

Nerve supply: Derived from the **pelvic/inferior hypogastric plexus** and consists of the following components:

Sympathetic: from T12 to L2 innervate uterus via hypogastric plexuses. The uterine tube is innervated by T11-L2. These are believed to be involved in vasoconstriction and uterine contraction.

Parasympathetic: via pelvic splanchnic nerves (S2- S4). These are believed to be vasodilator and inhibit muscular contraction.

Pain as a result of stretch, spasm and ischemia of the uterus travels to lower thoracic segments. Pain can be relieved by interrupting the afferent impulses traveling via the superior hypogastric plexus. Pain from the cervix is believed to be carried by the pelvic splanchnic nerves. Labor pains are felt low in the hypogastrium and a lower part of the back.

Lymphatic drainage: Cancer of the uterine cervix is the commonest form of female cancer. Lymph vessels within the uterus drain to its lateral margins. From here collecting vessels go in four directions: through the parametrium into the iliac nodes; laterally beside the uterine tube and ovarian artery to the para-aortic (lumbar) nodes; posteriorly through the uterosacral folds to the sacral nodes; lymphatic vessels follow the round ligament to the superficial inguinal lymph nodes. Lymphatics of cervix drain into a plexus in the broad ligament beside the cervix; these then drain to internal iliac, external iliac and sacral nodes.

4. **Ligaments of the uterus:** Three types of ligaments attach to the uterus:

a) Broad ligament: A double-layered peritoneal fold called the **broad ligament**; b) two **fibromuscular** ligaments: the **round** and **ovarian** ligaments. Note these are derivatives of the genitoinguinal ligament (gubernaculum) and are found in the broad ligament; and finally c) several powerful ligaments formed by condensations of pelvic fascia that connect the lateral sides of the supravaginal cervix to the pelvic walls.

Peritoneal ligaments:

Broad ligament Extends from the lateral margin of the uterus and is a double layered peritoneal fold that covers it. The broad ligament extends from the lateral margins of the uterus to the lateral wall of the pelvis and has the two layers: the anterior and posterior lamina of this ligament, are continuous above at a free edge enclosing the uterine tubes. They diverge below and laterally. The space between the two layers is occupied by connective tissue known as **parametrium.**

Broad ligament in fact is a "mesentery" of the uterus and depending on the structure that it suspends or is connected to, it is divided into three parts: the mesentery of the ovary from the posterior lamina is called the **mesovarium**. The mesentery of the uterine tube formed by both the anterior and posterior lamina is called the **mesosalpinx**. The rest of the broad ligament is specifically called the **mesometrium**.

Contents of the broad ligament

Uterine tubes lie within the free edge. The part of the broad ligament between the uterine tubes and the mesovarium is referred to as the **mesosalpinx**. The ovaries with their ligaments, ovarian

ligament and suspensory ligament, lie in the posterior lamina and round ligament of uterus lie in the anterior lamina of broad ligament.

Other structures include: **uterine artery and veins; uterovaginal plexus** of nerves; Ducts of Gartner (remnants of the mesonephric duct which in the male form the ductus deferens and the ejaculatory duct), remnants of cranial mesonephric tubules oophporon-.they lie in the mesosalpinx between the ovary and the uterine tube and paraoophoron - similar remnants lie closer to the uterus; and the pelvic fascia, the parametrium.

Fibromuscular ligaments:

Proper ligament of the ovary (ovarian ligament) lies in the posterior lamina and attaches the ovary to the uterine cornua. A part of the **round ligament** (10-12 cm long) lies in the **anterior lamina** of the broad ligament.

The round ligament commences from the uterine cornu courses in the broad ligament, enters the deep inguinal ring and passes through the inguinal canal to insert in the **labium majus** and it conveys a few lymphatics to the superficial inguinal lymph nodes.

Ligaments formed by condensations of pelvic fascia.

Transverse cervical ligaments (**cardinal or Mackenrodt's ligament**)

Tissues of the lower part of parametrium are condensed to form a dense mass of fibrous and smooth muscle tissue extending from the **lateral fornices** of the vagina and supravaginal cervix to the lateral walls of the pelvis. These tissues are called the **transverse cervical ligaments.** These ligaments may be regarded as the *static supports* holding the vaginal vault and the cervix upwards and backwards. *Uterine vessels run on its upper edge and the ureter pierces it*.

Uterosacral ligaments.

Well defined bundles of fibrous and plain muscle tissue attached to the supravaginal cervical area**,** and running posteriorly and upwards, curving round the lateral borders of the rectum to reach the front of the sacrum**.** They raise a fold of peritoneum- the **uterosacral fold.**

Besides the latter two ligamentous structures, which support the vagina support the uterus include: the following structures: the **pelvic diaphragm, urogenital diaphragm** and the **central tendon of the perineum** (perineal body). The **pelvic diaphragm**: These are amongst the most important supports of the uterus. The pubococcygeus muscles have only a relatively small gap between the opposite medial margins. The medial fibres insert into the vagina, the **pubovaginalis fibres** and support it directly**.**

Perineal body. This is a pyramidal **fibromuscular** mass intervening between the posterior **vaginal** wall and the **anal canal**, with its apex on a level with the junction of the middle and lower thirds of the posterior vaginal wall. It is slung from the bony pelvis by the urogenital diaphragm. Into its deepest portion pass the decussating fibres of the levatores ani. Also inserting into it are (a) the pairs of deep and superficial transverse perinei muscles, (b) pair of bulbospongiosus muscles, and (c) superficial fibres of the external sphincter.

If the perineal body is badly lacerated or stretched, this support is absent and there is nothing to prevent the lower end of the vagina from everting, carrying with it a portion of the posterior wall of the bladder called the **cystocele,** or a part of the rectum called the **rectocele**.

Episiotomy done to enlarge vaginal opening during childbirth and a surgical cut lateral to perineal body is done to avoid perineal tears.

The uterus in pregnancy

- The non-pregnant uterus is about the size of a fist (3 X 2 X 1"), weighs approximately 40 g, and is entirely a pelvic organ.
- At the third month of pregnancy, the fundus rises to the level of the **pubic symphysis.** The uterus is about the size of a grapefruit and is palpable in the abdomen just above the pubic symphysis.

- Fourth month the fundus is at the level of the **supracristal plane (L4 - L5).** The uterus is halfway up to the umbilicus.
- At the fifth month it is at about the level of the **umbilicus**
- At the seven month it is halfway between the umbilicus and the xiphoid process.
- At eighth month it is below the **xiphisternum.**
- At ninth month it reaches the xiphisternum and then it drops as the fetal head descends into the pelvis.
- At term the uterus enlarges to *about 20 cm in length and 1 kg* in weight.
- After childbirth the uterus contracts and reaches normal size in about 8wk.

4. The **vagina** is a fibromuscular tube extending from the **vaginal vestibule** to the cervix. The recess around the cervix is known as the **fornix**, with **anterior**, **posterior** and **lateral recesses**.

   It is the female organ of copulation and is part of the birth canal. It is about 10 cm long, lined by a mucous membrane made of stratified squamous epithelium, which is transversely rugose. It contributes significantly to protection of the female genital tract from invading micro-organisms.

   The long axis of the vagina is parallel to the plane of the pelvic brim and almost perpendicular to that of the cervix. Unlike the uterus the vaginal musculature is thin and the vagina itself is distensible. Lumen of vagina is flattened anteroposteriorly, and thus it has anterior and posterior wall. At its lower end the lumen has the shape of an H. The upper end of the vagina is deviated slightly to the left. The anterior wall is about 7.5 cm long and its posterior wall is about 10 cm. The cervix enters the anterior wall of vagina at its proximal end.

   Fornix: The region of the vagina surrounding the vaginal cervix is referred to as the fornix. In other words the vaginal vault forms an arched ring around the cervix. The circular recesses so formed are called **anterior, posterior, right and left lateral fornices.** The lower end of the vagina opens into the **vestibule** of the vagina. The orifice is a median cleft, located just behind the urethral orifice. The walls of the vagina are normally in contact except at the vault, where the cervix separates the anterior and posterior walls. The vaginal lumen is normally at an acid pH. Cells shedding from the surface of its stratified squamous epithelium contain glycogen, which is metabolised into lactic acid by resident bacteria. The low pH provides some protection against invading bacteria.

   Hymen: In the virgin the orifice is partly closed by a crescentic or annular fold of thick mucous membrane called the **hymen.** When the hymen is ruptured the tags of remnants are referred to as caruncle hymenales or carrunculated hymen. The hymen varies in shape - it may be cribriform, imperforate or even absent.

   Relations:

   Anterior: Upper half related to the **base or fundus of bladder**; lower half related to the **urethra.**

   Posterior: The **posterior fornix** is capped with peritoneum and separated from the upper third of the rectum by the rectouterine pouch. The upper two thirds of the vagina rests on the **ampulla of the rectum**, with loose connective tissue of the rectovaginal septum intervening. Lower third is separated from the **anal canal** by the **perineal body. Lateral relations**: The lateral fornix is related to the uterine artery and just below the latter the ureter. Stones in the ureter may be felt here.

   Sphincters of vagina: Apart from the weak circular muscle of the wall, three muscles form sphincters: the pubovaginalis fibres of the levator ani; the urogenital diaphragm; and the bulbospongiosus muscle (surrounding the greater vestibular gland and the bulb of the vestibule).

   Blood supply is derived from the vaginal uterine, internal pudendal and middle rectal arteries. Uterine and vaginal arteries: Note that the ureter passes under the artery about 2 cm lateral to the lateral fornix. In performing a hysterectomy it may be crushed inadvertently while clamping the artery.

Veins form a plexus around the vaginal wall and drain into the internal iliac veins.

Nerves are derived from pelvic plexuses and the lower part from the pudendal nerve.

Lymph from the lower part into the superficial inguinal nodes. The upper part drains into the internal iliac nodes.

5. **External genitalia:** Consists of the: **mons pubis**, **labia majora**, **labia minora**, **vestibule of vagina**, **greater vestibular glands.** *What are the lesser vestibular glands?*

   Mons pubis: Mons pubis: is a rounded elevation in front of the pubic symphysis and consists mainly of fat over the region of the pubic symphysis, covered by skin. After puberty coarse crinkly hair appear.

   Labia majora: Two elongated folds of skin, which run downward and backwards from the mons form the labia majora/majus. The outer aspects covered by skin containing many sebaceous glands. Hairs appear after puberty. Their inner aspects are smooth and hairless. The labia are united in front by an **anterior commissure.** The tendinous centre of the perineum projects posterior to the posterior commissure. Deep to the labia majora is subcutaneous fat within connective tissue. The round ligament inserts into the labia majora and carries lymphatics to the superficial inguinal lymph nodes.

   Pudendal cleft (vulval cleft). The space between the two labia majora is referred to as the pudendal cleft. The labia majora are homologues of the scrotum.

   Labia minora: Two small folds of hairless pigmented skin located between the labia majora, on either side of the vaginal opening. The bulbs of the vestibule and the greater vestibular lie deep to the skin of labia minora. The skin is very sensitive and has no hair or glands. The vestibule is closed off from view by these folds. They end posteriorly by joining the medial aspects of the labia major. Anteriorly each labium splits into medial and lateral parts. Lateral folds meet over the glans of clitoris to form its **prepuce**; medial folds meet below the glans to form its **frenulum.** The labia minora are devoid of fat and the skin covering them is smooth, moist and pink. In the virgin they are connected to each other by a sharp transverse fold of skin the fourchette (frenulum of the labia minora). Note: In the fourth week of pregnancy the labia take on a bluish coloration caused by estrogens. Varicosities may appear in the tenth week.

   Vestibule of vagina: is the cleft between the labia minora and opening into it are: the urethral orifice, vaginal orifice and the openings of the greater vestibular glands. The vestibule has the clitoris at its apex and the frenulum of the labia minora at its base. External urethral orifice is a median slit with slightly everted margins, situated 2.5 cm behind the clitoris immediately in front of the vaginal orifice. Vaginal orifice is a larger median cleft. In the virgin the hymen lies across it. Ducts of greater vestibular glands open at the posterolateral margins of the vaginal orifice. Several lesser vestibular glands open into the vestibule between the vaginal and the external urethral orifice.

   Clitoris: Is located at apex of the vestibule. It is the homologue of penis and is capable of enlargement. It lies hidden by the labia minora, with its **glans** covered by the prepuce. Like the penis the clitoris consists of essentially three columns of erectile tissue. The **body** of the clitoris consists of two corpora cavernous bound together by dense fibrous tissue. The corpora cavernous are the forward extensions of the crura, which attach to the ischiopubic rami. The **glans** is a small rounded tubercle at the free extremity of the clitoris. It is the modified forward end of the bulbs of the vestibule. It is very sensitive to sexual stimuli.

Materials: **Articulated skeleton**; **Prosected specimens**: of the superficial and deep abdomen with female viscera, prosected specimens of lateral pelvic walls (female), prosected specimen of external genitalia; **models:** female sagittal pelvis models, model: new pelvis, rubber & ligament etc. **X-rays:** DVD female perineum and reproductive organs.

TUTORIAL/LABORATORY CLASS 19
MALE REPRODUCTIVE SYSTEM

Aims: To describe the internal and external organs and structures of the male reproductive system, their blood and nerve supply and lymphatic drainage.

Specific Objectives

1. To identify the testes, their size, shape and location.
2. To label a macroscopic coronal section through the testes and scrotum.
3. To identify the parts of the epididymis and the ductus deferens. To identify the spermatic cord and name its main constituent structures.
4. To relate the coverings of the spermatic cord and testis to their derivation from layers of the anterior abdominal wall.
5. To describe the relationship of the inferior epigastric artery to the deep inguinal ring and rectus sheath.
6. To state the origin, course and termination of the ductus deferens.
7. To state the blood, nerve supply and lymph drainage of the testis.
8. To identify the seminal vesicles, prostate, and its lobes and ducts, and the bulbourethral glands.
9. To identify the penis and its attachments and component structures.
10. To state the blood and nerve supply and lymphatic drainage of prostate, seminal vesicles and penis.

Learning activities

1. Identify the **testes**, **epididymis**, **scrotum**, **spermatic cord** and **ductus deferens** on the models and prosected specimens. Read the lecture notes below and identify the major features of these structures.
2. To identify the main structure of the **spermatic cord**. List the structures that contribute to form the spermatic cord.
3. With colleagues, examine prosected specimens of the **prostate**. Identify five **lobes** of the prostate gland: an anterior, a posterior, two lateral lobes (right and left lateral lobes), and a median lobe. However histologically the prostate gland is recognized to have clinically important two major **zones**: central and peripheral. In addition there is a transitional zone (an anterior segment) and a preprostatic sphincteric zone.
4. Identify the **seminal vesicle** and **ejaculatory duct** in the prosected specimens and/or on the models.
5. Identify the **membranous urethra** on specimens and list the muscle, which surrounds this structure.
6. What are the **bulbourethral glands**, state their location and function? Identify the gland and its duct in the models of male sagittal pelvis.
7. Identify the **penis** and its component on models and specimens including **corpus spongiosum, corpus cavernosum** and **bulbospongiosus** and **ischiocavernosus muscles**.
8. With colleagues, summarise the blood and **nerve supply** to the testes, seminal vesicles and prostate, and to the penis.
9. Discuss the processes of erection and ejaculation.
10. **Discuss Clinical Problems 42 and 43.**

Lecture Notes

1. The **testes** are supported in the scrotal sac by the **spermatic cord** and the smooth **dartos** muscle of the scrotum. The left is usually at a lower level than the right. The **testes** are paired ovoid

organs, which produce spermatozoa after puberty. In the adult they weigh about 25 g. Each testis is said to have **superior** and **inferior ends**, **medial** and **lateral surfaces** and **anterior** and **posterior margins**. The posterior margin is covered by the epididymis and the lower part of the spermatic cord.

The **testes** are supported in the scrotal sac by the **spermatic cord** and the smooth **dartos** muscle of the scrotum. Each testis is said to have **superior** and **inferior ends**, **medial** and **lateral surfaces** and **anterior** and **posterior margins**.

The testis has an outer fibrous covering known as the **tunica albuginea**, which sends septa into the organ, dividing it into wedge-shaped **lobules**. Each lobule contains 1 to 4 **seminiferous tubules**. The lobules and septa converge near the posterior margin to form the **mediastinum testis**, which is a mass of fibrous tissue continuous with the tunica albuginea. The seminiferous tubules converge to form 20 to 30 **straight tubules** approaching the mediastinum. These in turn form a network known as the **rete testis** in the mediastinum itself. From here 15 to 20 **efferent ductules** leave the rete testis to enter the head of the epididymis.

The **tunica vaginalis** is the remnant of the fetal *processus vaginalis peritonei*, which precedes the descent of the testis from the abdomen to the scrotum. The tunica vaginalis is said to have **visceral** and **parietal layers**. The visceral layer covers the scrotum, medial and posterior surfaces of the epididymis and the sinus of the epididymis between epididymis and testis laterally. The tunica albuginea is covered by the **visceral layer of the tunica vaginalis**, which forms a sac within the scrotum.

The **epididymis** is attached to the posterior margin of the testis and consists of a **head**, a **body**, and an inferiorly pointing **tale of the epididymis**.

The **appendix of the testis** lies at the upper pole of the testis inferior to the head of the epididymis. It is the remnant of the paramesonephric duct. On the epididymeal head is a small pedunculated appendage known as the **appendix of the epididymis,** which is usually considered to be a remnant of the mesonephros.

The **blood supply** of the testis and epididymis is by the testicular a. from the aorta.

Venous drainage is to the IVC (Rt) or Lt renal v. (Lt) via the testicular v.

Lymph drainage from the testis is to the lateral and preaortic lymph nodes. Nerve supply is via the testicular plexus accompanying the testicular vessels.

Nerve supply: The nerve supply of the testes is derived from the testicular plexus. The testicular plexus is an autonomic nerve plexus composed of the sympathetic (T10) and parasympathetic nerves (Vagus). The sympathetic fibres derived from T10 segment of the spinal cord are continuation of the aortic plexus and these fibres are vasomotor to the testes. The testicular plexus receives some contribution from genitofemoral nerve and there is an evidence of contribution from posterior scrotal nerves. Thus testicular pain arising from squeezing or swelling is severe and produces a feeling of being sick. The pain is also referred to the lower abdomen and groin.

The ductus deferens This is a continuation of the tail of the epididymis. Initially it is very tortuous but, as it ascends in the posterior part of the spermatic cord, it becomes straighter, traversing the inguinal canal. As it exits the deep inguinal ring lateral to the inferior epigastric a., it leaves the spermatic cord to enter the lesser pelvis, where it passes on the lateral pelvic wall, medial to the obliterated umbilical a., obturator n. and vesical vessels.

Once it reaches the pelvis the ductus deferens crosses the ureter to pass between the posterior surface of the bladder and the upper pole of the seminal vesicle. Here it is dilated as the **ampulla of the ductus deferens**.

Note that the ductus deferens receives arterial supply from the **artery of ductus deferens** (from superior vesical a.).

2. The **scrotum** is an out pouching of the anterior abdominal wall and is thus a cutaneous fibromuscular sac containing the testis, epididymis and lower parts of the spermatic cord. The scrotum is divided into two halves externally by the **scrotal raphe**, which continues to the anus posteriorly and root of the penis anteriorly. The scrotal skin is thin and pigmented and overlies the **dartos muscle**. The scrotal muscle sends a **scrotal septum** between the testes.

   The scrotum, with the contraction of the cremaster muscle attached to the spermatic cord, responds to the ambient air temperature to elevate the testis close to the body in cold conditions. This is important to maintain the testis at the optimum temperature for spermatogenesis.

   The scrotum is supplied (nerves, vessels and lymph drainage) in a similar pattern to the labia in the female.

3. **The Spermatic Cord**

   As the testis descends through the inguinal canal it carries its vessels, nerves and **deferent duct** with it. Several other important structures lie within the spermatic cord: testicular a., cremasteric a., artery of the ductus deferens, **testicular vv (pampiniform plexus),** lymph vessels, genital br of genitofemoral n., cremasteric n., testicular sympathetic plexus, ductus deferens plexus (autonomic). These structures within the spermatic cord are all covered by external spermatic fascia, cremasteric fascia and internal spermatic fascia derived from the external oblique, internal oblique and transversalis fascia respectively. Note the transversus abdominis does not contribute to the layers of covering of the spermatic cord.

4. **The prostate:**

   The prostate gland is a fibromuscular and glandular organ that lies in the true pelvis surrounding the prostatic urethra in the male. Its secretions drain into the prostatic uretha by multiple prostatic ducts. It has a **base**, adjacent to the neck of the bladder; an **apex**, in contact with the fascia on sphincter urethrae; and **anterior**, **posterior** and right and left **inferolateral surfaces**.

   Lobes: It is composed of tubuloalveolar glands, fibrous tissues and smooth muscular tissue. After middle age, the prostate may increase in size projecting into the bladder, distorting and causing obstruction of the prostatic urethra. Structurally it is divided into 2 **lateral lobes (right and left)**, a **middle (or median) lobe** and an **anterior lobe** called **isthmus**, which is largely fibromuscular.

   Zones: However histologically the prostate gland is recognized to have two major **zones**: **central** and **peripheral,** which are clinically important. In addition there is a **transitional zone** (an anterior segment) and a **preprostatic sphincteric zone**. (Kumar and Majumdar, International Urology and Nephrology, 27 (3), pp. 231-243, 1995). The central and peripheral zones are quite distinct depending on the branching of the duct system, size of terminal sacculations, stroma and acini arrangements. The central and peripheral zones (homogenous in appearance) are located posteriorly and a majority of adenocarcinomas arise from this zone of prostate gland. The transitional zone situated anteriorly is heterogenous in appearance and is markedly involved in benign hypertrophy of the prostate gland. The ultrasonography of the prostate however does not clearly demonstrate the zonal anatomy but some distinction can be made in the structure of different zones.

   Functions: Prostatic secretions are of slightly acidic pH (6.5) and contain various enzymes including proteolytic and fibrinolytic enzymes and phospholipids. These secretions are milky white serous fluid, approximately 2 ml in volume (30% of volume of semen) and make an important contribution to the semen. The secetions are rich in acid phosphatase, citrate, calcium, fibrinolysin and prostaglandins. Note: the acid phosphatase levels are raised in the carcinoma of prostate and that is diagnostic of malignancy.

   Main function of prostatic secretions is: to provide mobility and viability to the sperms and neutralize acidity of the vagina that is lethal to the sperms. The secretions also contain seminalplasmin, an antibiotic that helps to prevent urinary tract infections in males.

Blood supply is from the **inferior vesical** and **middle rectal** aa. The prostate gland is surrounded by **prostatic venous plexus**, which also communicates with the venous plexus within the vertebral canal.

Nerve supply is from the **inferior hypogastric plexus** via the **prostatic plexus**.

Lymph drainage is to local nodes (**sacral, external and internal iliac** nodes). Prostate when enlarged can cause obstruction to the flow of urine and benign hypertrophy of prostate gland is one of the common causes of such complaints in an elderly male. Prostatic cancers are also common in males.

5. The **seminal vesicles** are coiled tubular glands, which produce fructose and a coagulating enzyme (vesiculase) for the seminal fluid. They do not store sperm; that is done within the epididymis (and possibly the ampulla of the ductus deferens).

   Each seminal vesicle is 5 cm long, but when the tube is uncoiled it is approximately 15 cm long and contains thin walled sacculated tube that folds on itself. The seminal vesicles (pair) at their distal end form a single duct that unites with the duct of ampulla of ductus deferens to form the ejaculatory ducts.

   They are related medially to the ampulla of the ductus deferens; are related anteriorly to the base of the bladder; and posteriorly to the rectum across the rectovesical fascia. The upper ends of seminal vesicles are covered by peritoneum of the rectovesical fold.

   Functions: seminal vesicles produce sticky viscous fluid that contributes to the bulk (60%) of the volume of semen. The fluid is alkaline in nature and rich in fructose, which provides carbohydrates and energy for the sperms. It also contains prostaglandins that impart mobility and viability to the sperms. Seminal vesicle secretions are yellow in colour and contain protein that helps semen to coagulate after ejaculation.

   Blood supply is from the **inferior vesical** and **middle rectal** aa.

   Nerve supply: is via inferior hypogastric plexus. The parasympathetic reaches the plexus from pelvic splanchnics (S2, S3, S4). Sympathetic reach from L1-L2, are responsible for the peristaltic waves of the seminal vesicle to empty their secretions during ejaculation. Note: if the L1 level of spinal cord is injured or diseased or the lumbar sympathetic ganglion is destroyed, it can lead to sterility in males.

6. **Ejaculatory ducts:** The ejaculatory ducts are 2 cm in length and open into the prostatic urethra alongside the prostatic utricle on the colliculus seminalis. The duct of the ampulla of ductus deferens unites with the duct of the seminal vesicle to form the **ejaculatory duct**.

7. **The penis:** The penis consists of a **root** attached in the perineum and a free, pendulous **body** or **corpus**. The root comprises three masses of erectile tissue. These are two **crura**, which attach along the ischiopubic ramus and are covered by the **ischiocavernosus muscle**; and the **bulb of the penis**, which lies between the two crura and is firmly attached to the inferior aspect of the fascia of the urogenital diaphragm. The bulb is surrounded by **bulbospongiosus muscle**. The bulb of the penis has the spongy urethra passing through it.

   The **body** of the penis is said to have a **dorsum**, which is posterosuperior during erection and an opposite **urethral (ventral) surface**. The body consists of two **corpora cavernosa** and a single **corpus spongiosum**. The crura are continuous with the corpora cavernosa of the body of the penis, just as the bulb of the penis continues as the corpus spongiosum in the body.

   The corpora cavernosa are enclosed in a strong fibrous **tunica albuginea**, which meet in the midline as the **septum of the penis**. The corpus spongiosum is expanded distally as the **glans of the penis**, which has a ridge known as the **corona glandis**, overhanging a grooved **neck of the penis**. The navicular fossa of the urethra is in the glans and opens onto the apex of the glans. The glans is covered by a **prepuce** or **foreskin**, arising from the body of the penis. A fold of skin passes from the prepuce to the glans on the urethral surface just proximal to the urethral opening. This is known as the **frenulum**.

The **body** of penis is supported by two **ligaments**: The **fundiform ligament** arises from the lower linea alba, splits into two lamellae, which skirt the penis and unite below with the scrotal septum. The **suspensory ligament** is deep to the fundiform and is attached above to the pubic symphysis and below blends with the penile fascia.

The interior of the penile consists of **cavernous spaces** (best seen in the corpora cavernosa). These spaces show numerous trabeculae arising from the fibrous sheaths of the corpora cavernosa. These create spaces, which are filled with blood during erection.

Arterial supply: deep and dorsal penile aa (to cavernous spaces) from the internal pudendal a. These supply the helicine aa in the erectile tissue.

Venous drainage: via deep dorsal v. to prostatic plexus.

Nervous supply: (S2 to 4)

i) perineal n. (from pudendal n.) to urethra,

ii) ilioinguinal n. to the root,

iii) dorsal n. of the penis (from pudendal n.),

iv) autonomic nn from the pelvic plexuses. Parasympathetic initiates vasodilation and erection. Sympathetic initiates ejaculation and vasoconstriction (loss of erection).

Lymph drainage is to superficial inguinal nodes, deep inguinal nodes and external iliac nodes.

8. **Erection, Emission and Ejaculation**

   Erection is produced by vasodilation of the helicine aa (parasympathetic action) leading to increased blood flow into the cavernous spaces. This causes compression of the veins near the exterior of the cavernous spaces, thus decreasing outflow and increasing pressure inside the erectile tissue and causing the erection of penis. At the same time the bulbourethral glands secrete mucus into the urethra.

   When there is increased sympathetic activity (eg during anxiety or after ejaculation) vasoconstriction of the helicine aa decreases blood flow into the erectile tissue and the penis becomes flaccid.

   Emission and ejaculation is under sympathetic control and is produced by contraction of the smooth muscle of the epididymis and ductus deferens, seminal vesicle and prostate. Some of the pelvic and UG diaphragm muscles (eg bulbospongiosus) undergo contraction to expel the semen.

   Note: Seminal fluid consists of seminal vesicle fluid (containing amino acids, prostaglandins, fibrinogen, fructose), prostatic secretions (an alkaline fluid), and bulbourethral gland secretion (mucus).

9. The **bulbourethral glands (Cowper's glands)** are about 1 cm in diameter, lie lateral to the membranous urethra above the perineal membrane and penile bulb and are enclosed by fibres of the sphincter urethrae. The excretory duct of each (3 cm in length) passes obliquely forwards, piercing the perineal membrane to open into the spongiose urethra about 2.5 cm below the perineal membrane.

Materials: **Articulated skeleton**; **Prosected specimens**: of superficial and deep abdomen, anterior abdominal wall (M), lateral male pelvic walls, loose testes, Male external genitalia specimen; **Models:** Torso models, pelvis bony and rubber models, lateral pelvic wall (M), **X-rays**; **DVD**: male perineum, and reproductive system.

TUTORIAL/LABORATORY CLASS 20

BLOOD VESSELS, LYMPHATICS AND NERVES OF THE PELVIS

Nerve supply: pp 24-31

Lymphatics: pp 32-39

Blood vessels: Refer to the lab and lecture notes above.

Materials: Models: torso, 2 deep abdomen sp. – (M & F), 2 post abdominal wall sp; 2 lateral pelvic wall/deep thigh sp. – (M & F), 2 lat. pelvic wall sp (M & F).; 2 models: sagittal section pelvis - male and female models, X-rays visceral and angiograms

TUTORIAL/LABORATORY CLASS 21:
REVIEW OF AUTONOMIC NERVOUS SYTEM

TUTORIAL/LABORATORY CLASS 22:
RADIOLOGY AND CROSS SECTIONAL ANATOMY OF ABDOMEN AND PELVIS; SURFACE ANATOMY OF ABDOMEN

APPENDIX 5

CLINICAL PROBLEMS
Note:
These clinical problems are included here for you to apply your anatomical knowledge to some clinical scenarios. You will not be assessed directly in the assessments but note that knowledge of answers to these problems may help to trigger an intrinsic motivation to your learning of the factual knowledge.

1. A wounded soldier had his sympathetic trunk severed in the neck on one side and interruption of the sympathetic supply to the head on that side occurred. The patient had a sympathetic disturbance known as Horner's syndrome. This syndrome consists of: pupillary constriction, ptosis, enophthalmos, and vasodilation and absence of sweating on the face and neck. Using your knowledge of anatomy explain these symptoms and discuss which other sympathetic pathway lesions may cause Horner's syndrome.

2. Following a severe cold, a patient complained of a frontal headache and a dull, aching pain in the right side of the face. What anatomical structures are likely to become secondarily infected from the nose?

3. A 60-year-old woman visited her physician with a swelling over the parotid gland on the right side. She stated that she had first noticed the swelling three months previously and since that time it had rapidly increased in size. Recently, she had noticed that the right side of her face "felt weak", and she could no longer whistle for her dog. On examination a hard swelling deeply attached to the parotid gland was found. On testing the facial muscles, it was found that the muscles on the right side were weaker than those on the left side. What is the connection between the parotid swelling and the right sided facial weakness? Which vessels and nerves lie within the parotid gland? What can be the cause of these symptoms?

4. A 70-year-old man visited his physician complaining of a small swelling below his chin. On examination a single small, hard swelling could be palpated in the submental triangle. It was mobile on the deep tissues and not fused with the skin. When examining the inside of the patient's mouth, a small, hard-based carcinomatous ulcer was found on the right side of the tip of the tongue. On questioning, the patient said he had noticed the ulcer for about 4 months, but since it did not cause much discomfort, he had ignored it. Using your knowledge of anatomy discuss this case.

5. Following a partial thyroidectomy in which difficulty was experienced in tying the left inferior thyroid artery, the patient was found to have unilateral partial section of the left recurrent laryngeal nerve. Describe the position assumed by the left vocal fold. What is the function of the recurrent laryngeal nerve? What is the course of the inferior thyroid artery in the neck? Where does this artery originate?

6. A 35-year-old woman had a partial thyroidectomy for the treatment of thyrotoxicosis. During the operation a ligature slipped off the right superior thyroid artery. In order to stop hemorrhage, the surgeon blindly grabbed for the artery with artery forceps. The operation was completed without further incident. The next morning the surgeon noticed that the patient spoke with a husky voice. Using your knowledge of anatomy, state what is most likely to have happened to the patient. What is the condition of the right vocal fold? Where does the superior thyroid artery originate? Into what vessel does the superior thyroid vein drain?

7. A patient is suspected of having a lesion of the glossopharyngeal nerve. How would you test the integrity of this cranial nerve?

8. A 7-year-old boy was suffering from a severe infection of the right middle ear (otitis media). Within the course of a week, the infection had spread to the mastoid antrum and the mastoid air cells (mastoiditis). The organism did not respond to antibiotics, so the surgeon decided to perform a radical mastoid operation. Following the operation it was noticed that the boy's face was distorted. The mouth was drawn upward to the left and he was unable to close his right eye. Saliva tended to accumulate in his right cheek and dribbled out of the corner of his mouth. What structure had been damaged during the operation and where?

9. A 17-year-old girl visited her dermatologist because of severe acne of the face. On examination it was found that a small abscess was present on the side of the nose. The patient was given antibiotics and was warned not to press the abscess. Why is it dangerous to squeeze or incise a boil on the face in the area bounded by the eye, nose and upper lip?

10. A 22-year-old medical student was struck by a golf ball on the left temple. He fell down unconscious but regained consciousness in about one minute. There was some bleeding on his head, superior to his left zygomatic arch. When the doctor arrived half an hour later he said he was sleepy and wanted to lie down. His left pupil was now moderately dilated and reacted sluggishly to light. Suddenly he became unconscious. His pupil on the left was widely dilated and did not respond to light. He was taken to the hospital where CT Scan revealed a fracture of the squamous part of the temporal bone and extradural hematoma. What artery was most likely torn and what is the origin of this artery?

11. A mother, on looking at her newborn baby lying on its back in a crib, was astonished to see its anterior abdominal wall bulging in and out with each respiration. Can you explain this in anatomical terms?

12. A patient suffering from right-sided pleurisy complained of pain over the tenth right intercostal space that extended downward and forward across the costal margin as far as the umbilicus. Explain in anatomical terms why the pain was felt over such an extensive area.

13. A patient with chronic asthma said that he found breathing easier during an attack when he held onto something secure, such as a tabletop. Is this likely to be true? Why?

14. Two days after a 2-year-old girl was eating some peanuts, she became febrile, developed a cough, and breath sounds to the right lobe were diminished. Explain these findings.

15. A 50-year-old man says that he "loses his voice" easily lately and finds that his clothes are too big. He has a persistent cough with occasional bloodstained sputum and he admits to smoking fifty cigarettes a day. On examination the left vocal cord is immobile and lies in the adducted position. A chest radiograph shows a mass in the left upper lobe impinging on the mediastinal shadow. Explain the symptoms and signs found.

16. A 15-year-old boy developed a severe cold and 3 days later his general condition deteriorated. He became more febrile and started to cough up bloodstained sputum. At first he had no chest pain, but later, when he coughed, he experienced a severe pain over the right fifth intercostal space in the mid-

clavicular line. The diagnosis of lobar pneumonia was made. Explain: (i) Why he did not experience chest pain early in the disease. (ii) What is the pain due to and why it is worse on coughing, (iii) Which lobe of the lung is likely to be diseased?
Note: Nerve Supply of Pleura. The phrenic nerve (C3, C4, C5) supplies the mediastinal and central diaphragmatic pleura. Intercostal nerves supply costal and peripheral diaphragmatic pleura. Stimulation of costal pleura elicits localized pain and also referred pain to lower portions of the thoracic wall and to the anterior abdominal wall.

17. A 50-year-old patient with a history of syphilis in her youth has a swelling that protrudes from beneath the upper margin of the sternum in the midline of the neck. The swelling expands with each systole of the heart. On examination, the trachea is displaced to the right in the neck and there is a distinct tugging sensation felt on palpation of the trachea. What anatomical structure lying within the superior mediastinum is likely to have an expansile swelling that tugs at the trachea?

18. A physician who was treating a patient who had acute pericarditis with a pericardial effusion decided he would aspirate some of the fluid. Where should he insert the needle and why?

19. A 45-year-old man has a history of rheumatic fever at age 10. Following the illness, stenosis of the mitral valve developed. He was recently admitted to the hospital with the signs and symptoms of right-sided heart failure. Based on your anatomical knowledge, by what method would you assess the size of the left atrium?

20. A 50-year-old man who experiences pain down the medial side of his left arm on exertion denies any heart disease, saying "I have no pain in my heart". Discuss this statement. Is it possible to cut the pain fibres to the heart? What are the effects of cutting all nerve fibres to the heart? Give an example.

21. During the physical examination of a 15-year-old girl a heart murmur was heard during auscultation at the second intercostal space, near the left sternal angle. On palpation, a continuous thrill (vibration) was felt. On questioning, the girl said that she had always been well, although she feels that she gets often "out of breath". Radiographs of the chest revealed slight left ventricular enlargement and slight prominence of the pulmonary artery. An ECG indicated a moderate degree of left ventricular hypertrophy. On an angiocardiogram, the ascending and arch of aorta appeared normal, but the left and right pulmonary arteries and descending aorta were opacified. The radiologist concluded that there was a shunt of blood through a patent ductus arteriosus. Discuss the location of ductus arteriosus and its prenatal function and postnatal closure.

22. A 75-year-old man with chronic bronchitis noticed that a bulge was developing in his left groin. On examination, an elongated swelling was seen above the medial end of the left inguinal ligament. When the patient coughed, the swelling enlarged, but did not descend into the scrotum. The patient had weak abdominal muscles. What is the diagnosis? Why did the swelling enlarge when the patient coughed?

23. A 9-week-old boy was admitted to the hospital with a swelling in the right groin that extended down into the upper part of the scrotum. When he cried, the swelling enlarged. On careful palpation it was possible to reduce the size of the swelling. The swelling was situated above and medial to the pubic tubercle on the right side. In anatomical terms explain what was wrong with the infant.

24. Following a sudden severe blow on the anterior abdominal wall from the hind leg of a horse, a patient complained of pain and swelling below the umbilicus. On examination, extensive bruising of the skin was observed over the lower part of the right rectus muscle. On gentle palpation, a deep swelling confined to the right rectus sheath was felt. Deep swelling was due to a collection of blood (haematoma). Which blood vessel was likely to have been ruptured?

25. While playing in his father's garage, a four-year-old boy swallowed some sulphuric acid, mistaking it for soft drink. Fortunately his mother was on hand and prevented damage to his mouth and

after treatment in hospital he returned home quite well. However, over the next three days, he increasingly complained of difficulty in swallowing, saying that the food "got caught" in the region of the sternal angle. Where are the likely sites of obstruction?

26. A 60-year-old woman was admitted to hospital unconscious and showing all the signs of severe internal hemorrhage, having vomited blood profusely before losing consciousness. She had a history of a chronic gastric ulcer in the posterior wall of the stomach. What large vessel(s) are likely to have been eroded?

27. A 35-year-old man with a long history of duodenal ulcer suddenly complained of severe epigastric pain. He was admitted to the hospital in a state of shock, and it was noticed that his anterior abdominal wall did not move on respiration. On examination, the abdominal musculature was noted to be rigid in the epigastrium. A perforated duodenal ulcer was diagnosed. Can you explain why the anterior abdominal wall failed to move on respiration? Why were the upper abdominal muscles rigid?

28. A 14-year-old girl complained of vague abdominal pain around the umbilical region after the evening meal one night. The pain increased in intensity yet seemed 'deep inside' and vomiting also resulted. At about midnight the pain shifted in position to the right iliac fossa where it was very localised, increased in intensity and seemed more superficial. At the hospital the abdomen, which was previously not particularly tender, was now very tender to palpation of the right iliac fossa and severe pain was experienced if the palpating hand were suddenly removed (rebound tenderness). Her inflamed appendix was removed at 12.45 a.m. Explain the nature of the pain and the changes that occurred.

29. A surgeon performing an appendicectomy was unable to find the inflamed organ because of extensive adhesions resulting from peritonitis the patient had two years previously. He could, however, find the colon. What anatomical feature of the colon will help him find the appendix?

30. A 45-year-old woman complained of colicky pain in the lower abdomen. She had noted that her bowel movements had recently become irregular, and she often had a strong desire to defecate, but succeeded in passing only bloodstained mucus. On vaginal examination the genital tract was found to be normal, but a firm, mobile swelling could be palpated through the posterior fornix, situated in the rectouterine pouch. Digital rectal examination revealed nothing more. Name the structure in the rectouterine pouch that is likely to be diseased. What additional examination should be performed?

31. A patient from a motor vehicle accident, apart from his broken right arm, facial lacerations and mild concussion, was tender over his left hypochondrium and he complained of pain at the side and also on his left shoulder. After removal of this ruptured spleen, his shoulder pain disappeared. Explain in anatomical terms.

32. A 60-year-old man was admitted to hospital for investigation of weight loss of 20 kg over six months and jaundice, which had been increasing over the past two months. There had been no history of pain but on examination, a soft round mass could be felt in the right side of the abdomen at the intersection of the transpyloric plane and the mid-clavicular line. This mass moved with respiration but was not tender. A diagnosis of cancer of the head of the pancreas was made. What anatomical structure is responsible for the mass and how does it arise?

33. Diseases of the gallbladder and the stomach produce pain or discomfort in the epigastrium. Trace the pain fibres from the gallbladder and stomach, and explain in anatomical terms why the pain sensation in these two organs is referred to the epigastrium.

34. A 35-year-old man woke at 2.a.m. with excruciating pain in the left loin, which radiated down to the pubic area, the penis and testes. The pain came in episodes and caused the man to roll around crying out and sweat profusely. His wife called the doctor who gave a large dose of analgesic drug intramuscularly and one hour later the pain settled. The next day an A-P X-ray of the abdomen revealed a calculus above the pelvic brim, at the left transverse process of LV 4.

(a) where is the calculus?
(b) why is the pain located over such an area?
(c) where else might the calculus have been found?

35. An intravenous pyelogram revealed that a patient's left kidney was in its normal position, but the right kidney was situated in front of the right sacroiliac joint. Can you explain this on embryological grounds?

36. A patient who had consumed large quantities of alcohol for most of his 50 years went to see his doctor because he was vomiting blood. His general practitioner discovered a large mass in the right hypochondrium, and a radiating group of veins around his umbilicus, and made a provisional diagnosis of cirrhosis of the liver with portal venous hypertension. Explain the symptoms and signs.

37. A young woman visited her obstetrician and was told that she was pregnant. She was instructed to exercise her pelvic floor twelve times a day. Explain how you would instruct the patient to carry out this exercise.

38. A 35-year-old man went to his physician complaining of pain on micturition. He said the pain was worse toward the end of the act and was sometimes referred to the end of his penis. He found that the pain was aggravated by jolting movements and relieved by lying down. Occasionally, he passed a few drops of blood at the end of micturition. Which pelvic organ is likely to be diseased? Why is the pain referred to the penis? Why is the pain relieved by lying down?

39. A 44-year-old woman who had attended a cancer detection unit was told that her Papanicolaou smear test was positive. She was admitted to hospital where a biopsy of the uterine cervix revealed a carcinoma and a hysterectomy was performed. What is the lymphatic drainage of the cervix and body of the uterus? Which important structure located lateral to the fornix can be accidentally damaged during hysterectomy?

40. A 40-year-old woman who had six children experienced pain during sexual intercourse (dyspareunia). Her local doctor found the fundus of the uterus could be palpated per rectum and that the cervix of the uterus was located 5cm above the vestibule of the vagina and pushing into the anterior vaginal wall.
(a) what is the normal position of the uterus?
(b) how much of the uterus can normally be felt per rectum?
(c) what are the normal supports of the uterus?
(d) why do you think the uterus is in its present position?
(e) what other symptoms might be present? Why?

41. During painful childbirth, relief is often obtained by injecting local anaesthetic into the epidural space of the lumbar spine and in the region of the ischial spines (per vaginam).
(a) what is the anatomical basis for each of these procedures?
(b) what special precautions would be necessary for each?

42. A 72-year-old man found increasing difficulty with micturition. His visits were frequent during the day and he had to get up at least four times during the night, but each effort was hardly worthwhile. He had difficulty in getting started, the stream was poor and occasionally there was a distressing dribble after he thought he had finished. What do you think was the cause of his problems? How would you help to verify this by clinical examination?

43. A 65-year-old man with a history of prostatic disease was found on radiological examination to have extensive carcinomatous metastases in his skull and lumbar vertebrae. His acid phosphatase level was abnormally high. Using your knowledge of anatomy suggest a possible route taken by the cancer cells as they migrate from the prostate to the lumbar vertebrae and the skull.

APPENDIX 6
GLOSSARY OF ANATOMICAL TERMS - 1987

Em. Prof. M.A. (Toby) Arnold (1907-1994)

Each entry is related to its Latin (L.) or Greek (G.) derivation, and the accented syllable (or syllables), as stressed in English, is followed by a (‘). Adjectives and participles functioning as adjectives are noted as adjectives. The terminology approved at the l980 meeting of the International Committee on Anatomical Nomenclature is used, with the anglicised equivalents.Vertebrae and cranial nerves are designated by Roman numbers.

Abbreviations used are:

a./aa. = artery, arteries
adj. = adjective
adv.= adverb
C. = cervical
CC. = costal cartilage
cf. = compare
Co. = coccygeal
e.g. = for example
L. = lumbar
lig./ligg. = ligament(s)
m./mm. = muscle(s)
n./nn. = nerve(s)
n. = noun
pl. = plural
R. = rib
T. = thoracic
S. = sacral
v./vv. = vein(s)
v. = verb
vx. = vessels

A (a)

abdom’en or ab’domen - L. abdomen = the belly, the part of the trunk between thorax and the perineum. (adj. - abdom’inal).
abduc’tion - L. ab = from, and ductum = led, hence, movement from. (v. - abduct).
access’ory - adj. L. accessum = added, hence, supplementary.
accommoda’tion - L. ad = to, and modus = measure, hence, adaptation of the optical power (focussing) of the eye for shorter distances.
acetab’ulum - L. acetum = vinegar (cf. acetic), and abulum = small receptacle, hence, a vinegar cup, hence, the socket for the head of the femur (adj. - acetab’ular).
acous’tic - adj. G. akoustikos, related to hearing.
acro’mion - G. akros = summit (cf. Acropolis) and omos = shoulder, hence, the tip of the shoulder.
adduc’tion - L. ad = to, and ductum = led, hence, movement towards (v. - adduct).
adhes’ion - L. ad = to, and haesus = stuck, hence, stuck to, e.g., a. in’terthalam’ica - variable and functionally insignificant.
adrener’gic - adj. L. ad = at, ren = kidney, and G. ergon = work, hence, stimuli which cause the adrenal (suprarenal) gland to produce adrenaline. Used to specify neurons or pathways which use adrenaline as a transmitter.
af’ferent - adj. L. ad = to, and ferent = carrying (cf. ferry), hence, carrying to, e.g., axons carrying information from retina to lateral geniculate nucleus are afferents to that nucleus.
agg’er (a’jer) nasi - L. = eminence of the nose.
ag’onist - G. agonistes = rival, hence, a muscle in apparent contest with another. Used for a prime mover.
a’la - L. wing, hence a wing-like process (pl. - a’lae).
albugin’ea - L. albus = white, G. gen = form, hence, like boiled white of an egg.
alimen’tary - adj. L. alimentum = food, e.g., alimentary canal.
allocor’tex - G. allos = other (than usual), and L. cortex = bark, hence non-laminated external grey matter. It refers to paleo- or archi-cortex, as distinct from neocortex.
alve’olus - L. a basin, hence any small hollow (pl. - alve’oli. adj. - alve’olar).
al’veus - L. = tray. The allusion is unclear. The alveus is a layer of fibres on the free surface of the hippocampus.
ambig’uus - adj. L. = doubtful (nucleus ambiguus).
ampul’la - L. = a two-handed flask, a local dilatation of a tube.
amyg’daloid - adj. G. amygdala = almond, and -oeides = like, hence, amygdaloid body is an almond-shaped mass.
anaesthe’sia - G. - an = negative, and aisthesis = sensation, hence, loss of semsation (adj. - anaesthet’ic).
analge’sia, - G. an = negative, and algesis = pain, hence insensibility to pain (adj. - analge’sic).
anastomo’sis - G. ana = of each, and stoma = mouth, hence the end-to-end continuity of 2 vessels (adj. - anastomo’tic).
anatom’ical position - see position.
anat’omy - G. ana = up, and tome = a cutting, hence cutting up of a body.
anco’neus - G. ancon = elbow, hence the muscle attached to the (lateral surface of the) olecranon.
an’eurysm - G. angeion = blood vessel, and eurys = wide, hence a pathological dilatation of a blood vessel.
angiog’raphy - G. angeion (v.s.), and graphe = a record, hence a picture of a blood vessel which has been injected with a dye or radiopaque material.
anhidro’sis (anhydrosis, anidrosis) - G. an = negative, and hidros = sweat, hence absence of sweating, typical of skin deprived of its sympathetic innervation.

an'kle - the region between the leg and the foot.
an'sa - L. a handle or loop. Applicable to nerves.
antag'onist - G. anti = against, and agonistes = rival, hence a muscle which may oppose an agonist.
anteflex'ion - L. ante = before, and flexere = to bend, hence anterior angulation between the body and cervix of the uterus.
ante'rior - comparative of L. ante = before, in front.
antever'sion - L. ante = before, and versum = turned, hence, the anterior angulation between cervix uteri and the vagina.
antidro'mic - adj. G. a = negative, and dromos = current, hence conducting in the opposite direction to the usual.
an'trum - G. antron - cave, hence a space in a bone or organ.
an'ulus or ann'ulus - L. anus = ring.
a'nus - L. a ring. (adj. - a'nal).
ap'oneuro'sis - G. apo = from, and neuron = tendon (later applied to nerve cell and its fibres), used for sheet-like tendons. (adj. - aponeuro'tic).
apoph'ysis - G. apo = from, and physis = growth, hence, a bony process - reserved for the articular process of a vertebra (adj. - apoph'ysi'al).
appen'dix - L. supplement.
aq'ueduct - L. aqua = water, and ductus = drawn or led off, hence a channel for conducting fluid, e.g. the cerebral aqueduct of the midbrain, which transmits fluid from the 3rd to the 4th ventricle.
arach'noid - adj. G. arachne = spider, and -oeides = like, hence like a spider's web. This middle layer of the three meninges is spread web-like over the brain when the dura has been removed.
ar'bor vi'tae - L. arbor = tree, and vita = life, hence, resembling the tree of life. This colourful term is used to describe the pattern of cerebellar folia seen in a median section.
ar'chicerebell'um - G. archi = first, hence the oldest part of the cerebellum, which is the flocculonodular lobe.
ar'chipall'ium - G. archi = first, and pall'ium = cloak, hence the cortex which developed first in vertebrates. Often synonymous with hippocampal formation.
ar'chistria'tum - G. archi = first, and L. stria'tum = streaked or fluted.
ar'cus - L. an arch, hence, ar'cuate - L. arcua'tum = curved or arched.
ar'ea - a part of a surface.
are'ola - L. small, open space.
arm - the upper limb, between shoulder and elbow.
arrec'tor - L. adrec'tus = raised, hence, arrector pi'li = a hair-raising muscle.
art'ery - L. arte'ria (which originally meant air- or wind-pipe, and later a blood vessel carrying blood away from the heart).
artic'ula'tion - L. ar'tus = joint, hence, artic'ulate - to form a joint.
ar'yte'noid - G. arytain'a = pitcher, and -oeides = like, hence the arytenoid cartilage because it curves like a spout.
as'pect - a view of more than one surface.
as'pera - L. rough.
as'trocyte, - G. as'tron = star, and ky'tos = cell, hence a star-shaped (neuroglial) cell.
atax'ia, - G. a = negative, and tax'is = order, hence inability to co-ordinate the voluntary muscles.
at'las - G. at'lao = I sustain. Atlas was a mythical god who sustained the globe on his shoulders. The 1st vertebra sustains the skull, and its upper surface bears 2 concavities which suggest Atlas' palms, not shoulders.
a'trium - L. = entrance hall (adj. - at'rial).
at'rophy - G. a = negative, and tro'phe = food, hence wasting from starvation.
aus'cultate - L. auscul'to = to listen to, hence, ausculta'tion, the act of listening to a bodily activity.
aur'icle - L. auric'ula = a little ear.
au'tonom'ic - adj. G. auto = self, and no'mos = law, hence self-regulating.
axil'la - L. armpit.
ax'is - L. ax'is = the central line of a body or part thereof, especially the imaginary line around which rotation takes place.
ax'on - L. axis = axis, hence tha main process of a neuron conducting impulses away from the cell body.
az'ygos - adj. G. a = negative, and zy'gos = paired, hence, unpaired.

B (b)

bas'ilar - adj. L. bas'is = base.
basil'ic - adj. G. basil'ikos = royal (king-sized).
bi'ceps - L. bis = double, and caput = head, hence 2-headed (adj. - bicipital).
bi'fid - adj. L. bis = double, and fin'do = to split.
bi'furcate - L. bis = double, and fur'co = fork, hence to divide into two.
bipen'nate - adj. L. bis = double, and pin'na = feather, hence converging from 2 sides.
body - the main part.
bor'der - see margin.
bra'chium - L. arm (adj. - bra'chial).
bra'chiocephal'ic - L. bra'chium = arm, and G. keph'ale = head, hence a blood vessel related to the upper limb and head.
branch'ia - G. = gills (adj. - branch'ial).
breg'ma - from a G. word implying moist, referring to the site of the anterior fontanelle (q.v.), a little fountain, the site of junction of the coronal and sagittal sutures, where the brain can be felt pulsating in infancy.
brev'is - L. = short - cf. brief.
bronch'iole - diminutive of bronch'us (q.v.).
bronch'us - derivation unhelpful - a branch of the trachea (adj. - bronch'ial).
bucc'al - adj. L. buc'ca = cheek.
bucc'inator - L. trumpeter - hence the muscle which blows air out from the cheek under pressure.
bul'bus - L. = bulb or onion.
bul'la - L. bubble.
bur'sa - G. a purse, hence a flattened sac containing a film of fluid.

C (c)

cae'cum (cecum) - L. = blind.
calcan'eus - L. calx = heel, hence the bone of the heel.
cal'car - L. a spur.
cal'car av'is - L. the spur of a bird, hence a spur-like elevation.
calf - the soft tissue swelling at the back of the leg.
callos'um - L. cal'lum = hard.
calva'ria - L. cal'va = bald head, hence the part of the skull containing the brain - i.e. cranium minus the facial skeleton.
ca'lix - L. a wine-cup.
canal' - L. canal'is = a water-pipe or canal.
canalic'ulus - diminutive of canal.
can'cellous - adj. L. cancelli = grating or lattice.
ca'nine - adj. L. can'is = dog.
can'thus - G. kan'thos - used at first for rim of eye, then angle between ends of rims.
capill'ary - L. capillar'is = hair-like, hence a very thin blood vessel.
cap'sule - L. cap'sa = box, hence an enclosing sheet.
cap'itate - adj. Having a cap'ut (q.v.).
cap'ut - L. head. Cap'itis - of a head (adj. - capitate - having a head - cf. decapitate).
capit'ulum - diminutive of caput.
car'diac - adj. G. kar'dia = heart.
cari'na - L. a keel.
car'neae - L. car'nea = fleshy.
carot'id - G. kar'oo, to put to sleep, because compression of the common or internal carotid a. may cause coma.
car'pus - G. wrist (adj. - car'pal).
car'tilage - L. gristle, hence, cartilag'inous = adj.
carun'cle - diminutive of L. caro = flesh, hence, a small fleshy elevation.
cau'da - L. tail. (adj. - cau'date - having a tail).
c. equi'na - a horse's tail.
ca'vernous - L. containing caverns or cave-like spaces.
cav'ity - L. cav'itas = a hollow.
ca'vum - L. cave.
cen'tral - adj. L. cent'rum = centre.
cent'rum - L. centre.
cephal'ic - adj. G. keph'ale - head.
cerebell'um - diminutive of L. cer'ebrum = brain.
cer'ebrum - L. = brain, adj. cerebral.
ceru'men - L. ce'ra = wax.
cer'vix - L. = neck (adj. - cervi'cal).
chias'ma - G. kiasma = cross. (The G. letter chi = c).
cho'ana - G. = funnel (pl. - choan'ae).
chon'dral - adj. G. chon'dros = cartilage.
chor'da - L. = cord.
cho'roid - adj. G. chorion = skin, hence, like a membrane.
chyle - G. juice
cil'ium - L. = eyelid, hence, an eyelash (adj. - cil'iary, or ci'liat'ed).
ciner'eum - L. cin'eris, of ashes.
cing'ulum - L. girdle or belt, adj. - cin'gulate.
cir'cumflex - verb and adj. L. cir'cum = around, and flex'ere = to bend, hence, bend or bent around.
cister'na - L. = a cistern.
claus'trum - L. clau'sum = closed, hence a barrier.
clav'icle - diminutive of L. clav'is = key - old Roman key was S-shaped.
cleido- - G. kleisis, a closing (by a key of a lock) = related to clavicle.
clin'oid - adj. G. kline = bed, -oid = like, hence, like a bed-post.
cli'vus - L. = slope (cf. declivity).
clunes – pl. of L. clunis = buttocks, nates.
coc'cyx - G. kokkyx = cuckoo, whose bill the coccyx resembles.
coch'lea - L. = snail, hence the spiral cochlea, adj. - coch'lear.
coe'liac - adj. G. koil'ia = belly.
coeru'leus - adj. L. blue, hence, loc'us coeru'leus, a group of nerve cells in the rostral pons coloured blue or black by melanin.
collat'eral - adj. L. con = together, and latus = side, hence, alongside.
collic'ulus - diminutive of L. col'lis = hill.
col'lum - L. = neck (cf. collar).
colum'na - L. = column, or pillar.
co'lon - G. ko'lon = large intestine.
com'itans - adj. L. = accompanying.
com'missure - L. con = together, and mis'sum = sent, hence fibres which cross between symmetrical parts.
commun'icans - adj. L. = communicating.
con'cha - L. = shell.
con'dyle- G. kondylos = knuckle.
con'fluens - L. con = together, and fluens = flowing, hence the meeting of more than one stream.
conjuncti'va - L. con = with, and junct'us = joined (cf. junction), hence the continuous bulbar and palpebral lining membrane.
constrict'or - L. con = together, and strict'um = drawn tight, hence, producing narrowing.
con'tour - G. tor'nos = lathe, hence a line which turns - an outline.
co'nus - L. = cone, co'nus medullar'is - the lower end of the spinal cord.
cor'acoid - adj. G. kor'ax = a crow, hence, like a crow's beak.
corn'ea - L. cor'nu = horn, hence, the dense tissue forming the front of the eyeball.
cor'nu - L. = horn.
coro'na - L. = crown. adj. - cor-onary or coro'nal; hence a coronal plane is parallel to the main arch of a crown which passes from ear to ear (cf. coronal suture).
corono'id - adj. G. koro'ne = a crow, hence, like a crow's beak.
cor'pus - L. = body, pl. - cor'pora.
cor'rugator - L. con = together, and ruga = wrinkle, hence a muscle that produces wrinkles.
cor'tex - L. = bark, adj. cortical.
cos'ta - L. = rib. adj. - cos'tal.
cox'a - L. = hip, hence os cox'ae = the hip bone.
cran'ium - G. kran'ion = skull. (In anthropology = skull minus mandible) adj. - cranial.
cremas'ter - G. = suspender, hence the muscle

which suspends the testis.
crib'riform - adj. L. crib'rum = sieve, hence, sieve-like.
cric'oid - adj. G. krik'os = ring, hence, ring-like, i.e. circular.
crist'a - L. = crest, cris'ta gal'li = the (median) crest of a cock.
cru'ciate - adj. L. crux = cross, hence, crossed like the letter X.
crus - L. = leg. pl.: cru'ra.
cub'ital - adj. L. cub'itus = elbow.
cub'oid - adj. G. kuboid'es = cube-shaped.
cul'men - L. = summit (cf. culminate).
cun'eiform - adj. L. cun'eus = wedge, hence wedge-shaped.
cu'pula - L. = dome.
cusp - L. cusp'is = a pointed elevation.
cuta'neous - adj. L. cut'is = skin.
cyst - G. kyst'is = bladder, adj. - cyst'ic.

D (d)

de'clive - L. decliv'itas = slope (cf. clivus).
decussa'tion - L. decussa'tus = crossed like the letter X.
deep - further from the surface.
def'erens - adj. L. = carrying down.
degluti'tion - L. degluti're = to swallow, hence the act of swallowing.
del'toid - adj.G. del'ta (D). The capital has a triangular shape (cf. the delta of the Nile river).
den'drite or den'dron - G. = a tree, hence like the branches of a tree.
dens - L. = tooth (cf. dentist), adj. - den'tal.
den'tate - L. dens = tooth, hence, having a toothed margin.
depress' - L. de = prefix implying descent, and press'um = pressed, hence to press down, and depression = downward movement or a concavity on a surface.
der'matome - G. der'ma = skin, tome = a cutting or division, hence a segment of skin supplied by a single spinal ganglion.
der'mis - G. = skin, adj. - der'mal.
detru'sor - L. detru'sio = thrust away.
di'aphragm - G. dia = across, and phrag'ma = wall, hence, a partition, adj. - diaphragmat'ic.
diaph'ysis - G. dia = apart, and physis = growth, hence, the body of a long bone between the growing regions near the ends.
dias'tole - G. dia = apart, and stell'ein = sending, hence sending the walls of the heart apart, i.e. relaxation or dilatation. Adjecive - diastol'ic.
dienceph'alon - G. dia = between, and enkeph'alos = brain, hence in general the structures surrounding the 3rd ventricle. adj. - diencephal'ic.
digas'tric - adj. G. dia = double, and gas'ter = belly, hence, 2-bellied.
dig'it - L. dig'itus = a finger or toe, usually excepting the pollex or hallux, adj. - dig'ital.
dip'loë - G. = fold, hence the cancellous bone between the inner and outer tables of the skull. adj. - diplo'ic.
diplo'pia - G. diplo'os = double, and op'sis = vision, hence double vision.
dis'cus - L. = disc.
dist'al - adj. L. di = apart, and stans = standing, hence, standing apart, implying farther from a given point, usually the root of a limb.
divertic'ulum - L. = by-road, hence a blind tubular process or sac.
dor'sal - adj. L. dor'sum = back.
duc'tus - L. = duct.
duode'num - L. duodenar'ius = twelve, because it is 12 FBs long.
du'ra - adj. L. = hard (cf. durable); dura mater, the tough covering membrane of the central nervous system.
dyspha'gia - G. dys = difficult, and phagein = to eat, hence, difficulty in swallowing.

E (e)

ectop'ic - G. ek = out, and topos = place, hence out of place.
edge - border or margin of a surface.
ef'ferent - adj. L. ex = out, and ferens = carrying, hence, conducting from.
el'bow - the junction between arm and forearm.
el'evate - L. eleva'tus = raised up, hence, to raise up, and eleva'tion = a raised part.
emboliform'is - adj. G. em'bolus = wedge or blocking matter.
em'inence - L. em'inens = projecting, hence, a projection (usually smooth).
emissary - adj. L. e = out, and emiss'um = sent out; emissary v., one connecting intra- with extra-cranial venous channels.
enceph'alon - G. en = within, and keph'alos = head, hence, the brain.
en'docar'dium - G. en'do = within, and kar'dia = heart, hence, the endothelial lining of the chambers of the heart.
en'docra'nium - G. en'do = within, and kranion = skull, hence, the outer endostial layer of the dura mater.
en'dolymph - G. en'do = within, and L. lymph'a = clear water, hence the fluid within the membranous labyrinth of the internal ear.
en'dome'trium - G. en'do = within, and me'tra = uterus, hence the mucosal lining of the uterine lumen.
epen'dyma - G. = an upper garment. It may refer to a vest or singlet, i.e. an under-garment, hence, the lining membrane of the ventricles of the brain and central canal of the spinal cord.
epicar'dium - G. ep'i = upon, and kar'dia = heart, hence, the visceral layer of serous pericardium which covers the heart.
epicon'dyle - G. ep'i = upon, and kon'dylos = knuckle, hence a prominence on a condyle of the humerus or femur.
epicra'nial - adj. G. ep'i = upon, and kra'nion = skull, hence, the epicranial aponeurosis (galea) connecting frontalis mm. to occipitalis mm.
epidid'ymis - G. ep'i = upon, and did'ymos = testis, hence, the organ perched posterosuperior to

the testis.
epidu'ral - adj. G. ep'i = upon, L. du'ra = tough, hence, external to dura mater.
epigas'trium - G. ep'i = upon, and gas'ter = belly, hence, the upper median zone of the abdomen.
epiglot'tis - G. ep'i = upon, and glot'tis = larynx, hence the uppermost part of the larynx.
epiph'ysis - G. ep'i = upon, and phy'sis = growth, hence, the end of a long bone beyond the cartilaginous growth disc, adj. - epiphysi'al.
epiplo'ic - adj. G. epiplo'on = a net, which the greater omentum resembles with fat entangled in it.
erec'tor - L. erec'tus = straight or upright.
eth'moid - adj. G. eth'mos = sieve, hence, like a sieve; an unpaired skull bone.
ever'sion - L. e = out, and ver'sum = turned, hence turned outwards.
exophthal'mos - G. ex'o = out, and ophthal'mos = eye, hence, prominent eyeball.
extend' - L. exten'do = extend or stretch out, hence, exten'sion = extended or straightened, hence, the position opposite to the flexed or bent position.
exter'nal - adj. L. = exter'nus = outward, hence, further from the inside.
ex'traperitone'al - adj. L. ex'tra = outside, G. per'i = around and tein'ein = stretched, hence outside the serous membrane stretched around the inside of the abdominal wall and around the viscera.
ex'trapyram'idal - L. ex'tra = outside, and pyramidal (q.v.), hence descending nerve tracts that do not traverse the pyramids of the medulla.
extrin'sic - L. extrin'secus = from without, hence (usually) a muscle (usually) originating outside the part on which it acts.

F (f)

fabel'la - diminutive of L. fa'ba = a bean, hence, a sesamoid bone found in the lateral head of gastrocnemius.
fa'cet - L. fa'cies = face, hence a small smooth bony surface, either coated with articular cartilage or the site of a tendinous attachment (cf. a facet on a diamond).
facil'itate - L. fa'cilis = easy, hence, to make easy.
falx - L. = sickle, hence, the sickle-shaped falx ce'rebri and falx cerebel'li, adj. - fal'ciform.
fas'cia - L. = band or bandage, hence the fibrous wrapping of muscles - deep f., or the subcutaneous layer of fatty connective tissue - superficial f., adj. fas'cial.
fasci'culus - diminutive of L. fas'cis = bundle, hence, a bundle of nerve or muscle fibres.
fasti-gius - L. fasti'gium = summit, hence the peak of the 4th ventricle, adj. - fasti'gial.
fau'ces - L. = throat, adj. - fau'cial.
fe'mur - L. = thigh, adj. - femoral.
fenes'tra - L. = window.
fi'bril - diminutive of L. fi'bra = a fibre.
fi'bre - L. fibra = a fibre, adj. L. fibro'sus = fi'brous.
fi'bula - L. = brooch, which the tibia and fibula resemble, the fibula representing the movable pin, adj. - fi'bular.
fi'lament - L. filament'um = a delicate fibre, adj. - filamen'tous.
fi'lum - L. = a thread. Fi'lum termina'le - a thread of pia continuous with the lower end of the spinal cord.
fim'bria - L. = a fringe, hence, fim'bria hippocam'pi, a scalloped band of fibres alongside the hippocampus.
fiss'ure - L. = a cleft.
fixa'tor - L. fix'us = fixed, hence, a muscle which fixes a part.
flac'cid - adj.. L. flac'cidus = weak or slack.
fla'vum - adj., L. fla'vus = yellow.
flex - L. flex'um = bent, hence, flex'or, a muscle which bends a part of the body, and flex'ion = the act of flexing.
flex'ure - L. flex'ura = a bending.
floc'culus - diminutive of L. floc'cus, a tuft. Hence resembling a picture of a little cloud, with a woolly top and a flat base, as in floc'culus cer'ebel'li.
foe'tus (fe'tus) - the developing mammal in utero; in Man, after the 2nd month in utero, adj. - foe'tal or fe'tal.
fo'lia - plural of L. fo'lium = leaf.
fol'licle - L. folli'culus = a little bag. adj. - folli'cular.
fontanelle' - French diminutive of L. fons = fountain, associated with the palpable pulsation of the brain in the anterior fontanelle of an infant.
fora'men - L. = hole.
for'ceps - L. = tongs.
fore'arm - the upper limb between the elbow and the wrist.
for'nix - L. = arch (hence fornica'tion, because the Roman prostitutes plied their profession beneath the arches of the bridges over the river Tiber).
fos'sa - L. = a ditch or trench, hence a concavity in bone, or an organ, or on a lining surface.
fo'vea - L. = a pit (usually smaller than a fossa).
fove'ola - diminutive of fo'vea.
fren'ulum - diminutive of fre'num.
fre'num - L. bridle or curb.
fron'tal - adj. L. frontis = of the forehead, or coronal.
fun'diform - adj.. L. fun'dus = bottom or base (cf. fundamental), hence, sling-shaped.
fun'dus - L. = bottom or base. (But note that the fundus of the stomach and uterus are at the top, and the fundus of the eye and of the bladder are posterior!).
funi'culus - diminutive of L. fu'nis = cord (used usually for bundles of nerve fibres).
fu'siform - adj. L. fu'sus = spindle, hence, spindle-shaped.

G (g)

ga'lea - L. = helmet, hence, ga'lea apo'neuro'tica - the aponeurosis of occipitofrontalis m.
gal'lus - L. = cock, hence, cris'ta gal'li, the cock's comb.
gam'ma - the 3rd letter of the G. alphabet, typically

used in a naming sequence - al'pha, be'ta, gam'ma, del'ta, etc.
gang'lion - G. = swelling, referring to a peripheral collection of nerve cells.
adj. - ganglion'ic.
gastric, gastro- - G. gas'ter = belly or stomach.
gastrocne'mius - G. gas'ter = belly, and kne'me = leg, hence, the bulging muscle of the calf.
gemel'lus - L. diminutive of gem'inus = twin.
ge'nial - adj. G. gen'eion = chin.
genic'ulate - see geniculum.
genic'ulum - L. genic'ulare = to flex the knee, hence, a bent knee.
gen'ital - adj.. L. genital'is = reproductive, hence, genital'ia, the sexual organs.
ge'nu - L. = knee.
gin'giva - L. = gum (of tooth).
gir'dle - a ring of bones which may be complete or incomplete.
glabel'la - diminutive of L. gla'ber = bald, hence a smoooth bony prominence between the eyebrows.
gland - L. glans = an acorn, adj. - glan'dular; a secreting organ.
gland'ula - diminutive of L. glans = acorn.
gle'noid - adj. G. gle'ne = socket.
gli'a - G. = glue, hence, an adhesive connective tissue.
glo'bus - L. = a globe.
glomer'ulus - L. glomera're = to roll up, from glo'mus = a ball of thread (cf. conglomeration).
glos'sa = G. tongue, adj. - glos'sal.
glot'tic - adj. See glottis.
glot'tis - G. = larynx, hence, the boundaries of ri'ma glot'tidis.
glute'al - adj. G. glou'tos = rump or buttock.
glute'us - G. glute'os = rump or buttock. One of 3 muscles of the buttock, adj. - glute'al.
gon'ad - G. = reproduction, hence a gland producing gametes - ovary or testis, adj. - gonad'al.
grac'ilis - adj. L. = slender.
granula'tion - diminutive of L. gra'num = a grain.
grav'id - adj. L. grav'ida = pregnant.
gris'eum - adj. L. gris'eus = bluish or pearly grey.
gubernac'ulum - L. something which governs or directs, like a rudder (cf. gubernatorial).
gy'rus - G. gy'ros = circle, hence a coil of brain cortex.

H (h)

haben'ula - diminutive of L. habe'na = rein.
hal'lux - L. hal'lex = great toe (hallu'cis = of the great toe).
ham'ate - adj. L. ha'mus = a hook, hence, hooked.
ham'strings - the tendons of the muscles of the ham - i.e. of the back of the thigh - felt posterior to the knee when the leg is flexed against resistance (semimembranosus, semitendinosus and biceps femoris).
ham'ulus - diminutive of L. ha'mus = hook.
haus'tra - L. = saccules.
helicotre'ma - G. he'lix = a coil, and tre'ma = hole, hence the aperture at the apex of the bony cochlea whereby scala vestibuli communicates with scala tympani.
he'lix - G. = coil.
hemianop'ia (hemianop'sia) - G. hem'i = half, an = negative, op'sis = vision, hence loss of half of the field of vision.
hemipare'sis - G. hem'i = half, pare'sis = paralysis, used usually to denote weakness rather than paralysis.
hemiple'gia - G. hem'i = half, ple'gia = stroke, hence, paralysis of one half of the body.
hem'isphere - G. hem'i = half, sphai'ra = ball, hence, half of a sphere.
he'par - G. = liver. adj. - hepat'ic.
her'nia - L. = a protrusion. adj. - her'nial.
hia'tus - L. = a gap (like that between some people's ears).
hi'lum - L. = the point of attachment of a seed, hence the part of an organ where the vessels and nn. are attached; adj. - hi'lar.
hind'brain - the part of the brain inferior to tentorium cerebelli, comprising medulla oblongata, pons and cerebellum.
hip - the lateral prominence of the hip bone and greater trochanter.
hippocam'pus - G. hippokam'pos = a sea-horse, hence, the curled shape of the hippocampus in coronal section; adj. hippocam'pal.
homo'logous - adj. G. hom'os = same, and log'os = word, hence a part with similar morphology but different function.
horizon'tal - adj. - parallel to the horizon.
horn - a projection, often pointed.
hu'merus - L. = the arm-bone.
hu'mour - L. humor = liquid, hence the aqueous and vitreous humour of the eyeball.
hy'aline - adj. G. hy'alos = glassy.
hydroceph'alus- G. hy'dor = water, koi'los = head. cf. cephalic.
hy'men - G. = membrane; across the virginal vagina.
hy'oid - adj. G. = U-shaped.
hyperacu'sis - G. hy'per = over, and akou'sis = hearing, hence excessive sensivity to sound.
hypoglos'sal - adj. G. hy'po = under, and glos'sa = tongue.
hypoph'ysis - G. hy'po = down, phy'sis = growth, hence, a downgrowth (from the brain). However, this is not the whole truth. Part is an upgrowth from the pharynx. adj. - hypoph'ysi'al.
hypothal'amus - G. hy'po = under, and thal'amus (q.v.), refers to part of diencephalon.

I (i)

il'eum - G. eil'ein = twisted. adj. - il'eal.
il'ium - L. the bone of the flank, adj. - il'iac.
i'ma - adj. L. = lowest, hence a. thyroidea i'ma.
im'par - L. = unpaired.
inci'sor - L. inci'sum = cut up.
incisu'ra - L. = notch.
in'cus - L. = anvil, hence the anvil-shaped ossicle of the middle ear.
in'dex - L. = a pointer, hence, the fore-finger.
indu'sium - L. = tunic.

infe'rior - adj. L. = lower down, hence, farther from the head end.
in'fra- L. = below.
infundi'bulum - L. = funnel.
in'guinal - adj. L. inguen = groin.
inhibi'tion - L. inhi'bitus = restrained, hence, reduction of the excitability of a synapse.
in'nervate - L. in = into, and ner'vus = nerve, hence, to supply a nerve to a part.
in'sert - L. inser'tio = to join into, implant, hence, to attach; noun - inser'tion.
inspec'tion - L. inspec'tus = examined, hence, visual examination.
in'sula - L. = island.
integ'ument - L. in = on, teg'men = roof, hence the skin coat.
in'tercala'ted - adj. L. in'ter = between, and cala'tum = inserted, hence interposed.
in'terdi'gitate - L. in'ter = between, and di'gitus = a digit. Hence, to interlock like fingers.
inter'nal - adj. L. inter'nus = inward, hence, nearer the inside.
in'ternun'cial- adj. L. in'ter = between, nun'cius = messenger.
in'tersti'tial - adj. L. in'ter = between, and sis'tum = set, hence, set between.
intes'tine - L. intes'tinum = the digestive tube beyond the stomach.
in'tima - L. = innermost.
in'tra- L. = within.
in'trafu'sal - adj. L. in'tra = within, fu'sus = spindle.
intrin'sic - adj. L. = on the inside.
i'ris - L. = a rainbow.
is'chium - G. is'chion = socket, because the ischium contributes more than either the ilium or pubis to the acetabulum.
i'so - G. = equal.
isth'mus - G. isth'mos - a narrow passage.

J (j)

jeju'num - L. jeju'nus = empty, adj. - jeju'nal.
joint - the meeting of 2 or more bones or cartilages, at which movement is possible.
jug'ular - adj. L. jugu'lum = neck.
ju'gum - L. = yoke (cf. conjugal).
jux'ta- L. = near.

K (k)

kinoci'lium - G. ki'neo = to move (cf. kinetic), and ci'lium L. = eyelash, hence protoplasmic thread of hair process in cupula of crista ampullaris of a semicircular duct.
knee - the junction of the thigh and the leg.
ko'niocor'tex - G. konis = dust, and L. cor'tex = bark, hence, sensory cortex containing mostly granular layers.

L (l)

la'bium - L. = lip (pl. la'bia), adj. - la'bial.
la'brum - L. = rim.
la'byrinth - G. labyrin'thos = maze, adj. - lsbyrin'thine.
lac'rimal - adj. L. lac'rima = a tear (drop).
lacta'tion - L. lact'ans = suckling. Hence, the act of secreting milk.
lac'tic - adj. L. lac = milk.
lactif'erous - adj. L. lac = milk, and fer're = to carry.
lacu'na - L. la'cus = lake, hence, a small pond or gap, adj. lacunar.
lamb'doid - adj. G. lamb'da, representing a capital 'L' and written as an inverted V; hence, like that letter.
lamel'la - diminutive of L. lam'ina = plate; hence, a small plate.
lam'ina - L. = plate, either a layer of nervous tissue, like the laminae of the lateral geniculate body, or a connective tissue membrane, like lamina cribrosa sclerae, or of bone, as in vertebral laminae; hence, laminec'tomy = lamina + G. ek'tome = excision - excision of the vertebral laminae to give access to the spinal cord; adj. - lam'inar.
la'rynx - G. = voice-box, adj. - larynge'al.
lat'eral - adj. L. la'tus = side, hence, nearer the side.
latiss'imus - superlative of adj. L. la'tus = wide, hence, latiss'imus dor'si m., the widest muscle of the back; earlier name was anitersor - wiper of the anus.
leg - the lower limb between the knee and the ankle.
lemnis'cus - G. lemnis'kos = a band or ribbon (applied to nerve fibres).
lens - L. = lentil - a transparent body with one or both surfaces curved to re-direct light rays, adj. - len'tiform or lenti'cular.
lep'tomen'inx (pl. l.-menin'ges) - G. lep'to = delicate, and men'inx = membrane. Usually refers to pia and arachnoid.
leva'tor - L. = elevator.
lien - L. = spleen, adj. - li'enal.
lig'ament - L. ligamen'tum = bandage, usually tying parts to each other, adj. - ligamen'tous.
lim'bus - L. = a margin, usually curved, hence, limbus of cornea, its circular junction with the sclera, adj. - lim'bic; limbic lobe of the brain comprises structures which encircle the junction of the diencephalon and telencephalon.
li'men - L. = a threshold, hence, sublim'inal - below threshold.
lin'ea - L. = line.
lin'gua - L. = tongue, adj. lin'gual.
lin'gula - diminutive of lin'gua, hence, a little tongue, adj. - ling'ular.
lis'sencephal'ic - adj. G. lis'sos = smooth, hence, a cerebrum lacking sulci.
lo'bule. Diminutive of lob'us.
lo'bus - G. lo'bos = lobe, adj. - lo'bar.
lob'ulus - L. diminutive of lob'us, hence, a lobule.
lo'cus - L. a place (cf. location, locate, dislocate).
loin - L. lum'bus - the part of the back between the ribs and the hip bone.
lon'gitu'dinal - adj. L. longitu'do = length, hence, lengthwise.
lon'gus - adj. L. = long, hence, longiss'imus (superlative) = the longest.
lum'bar - adj. - see loin.
lum'brical - L. lum'bricus = worm, hence worm-shaped muscles of the palm.

lu'men - L. = opening, hence the space within a tube.
lu'nate - adj. L. lu'na = moon, hence, crescentic.
lu'teum - adj. L. = yellow.
lymph - L. lymph'a - clear spring water.
lympha'tic - a vessel carrying lymph.

M (m)

mac'roscop'ic - adj. G. mak'ros = large, and sko'pein = to examine; hence, large enough to be seen with the naked eye, e.g., pertaining to gross anatomy.
ma'cula - L. = spot (cf. immaculate - spotless); adj. - macular.
malle'olus - diminutive of L. mall'eus = hammer, adj. - malle'olar.
mam'ma - L. = breast; adj. - mam'mary.
mammil'la - diminutive of mam'ma; adj. - mammil'lary.
man'dible - L. mandere = to chew; hence, the movable lower jaw; adj. - mandib'ular.
manu'brium - L. = handle; adj. - manu'brial.
ma'nus - L. = hand (cf. manual).
mar'gin - the edge or border of a surface; adj. - mar'ginal.
mas'seter - G. = chewer; adj. - masseter'ic.
mas'toid - adj. G. mas'tos = breast or teat.
maxil'la - L. = jaw-bone; now used only for the upper jaw; adj. - maxil'lary.
mea'tus - L. = passage; adj. - mea'tal.
me'dial - adj. L. me'dius = middle; hence, nearer the median plane.
me'dian - L. media'nus = in the middle.
me'diasti'num - derivation doubtful, but possibly from L. me'dius = middle, and stans = standing; hence, a median vertical partition, adj. - me'diasti'nal.
medul'la - L. = marrow; applied to part of an organ deep to its cortex, and to the spinal cord and adjoining part of brain stem, which may have been thought to be the marrow of the vertebral column, adj. - med'ullary pertains to the medulla of an organ or medulla oblongata.
mem'brane - L. membrana = a thin sheet; adj. - mem'branous.
menin'ges - plural of G. meninx = a membrane; adj. - meninge'al.
menis'cus - L. men'is - a small crescent.
men'tal - adj. - L. mentum = chin; or L. mens = mind.
mes'enceph'alon - G. me'sos = middle, and enkeph'alos = brain; adj. - mes'encephal'ic.
mes'entery - G. me'sos = middle, and en'teron = intestine; hence, the peritoneal fold which tethers the centrally situated small intestine; adj. - mesenter'ic.
me'sial - adj. - medial, used in dental anatomy.
me'sosal'pinx - G. me'sos = middle, and sal'pinx = tube; hence, the intermediate part of the broad lig.
met'acar'pus - G. met'a = after, and kar'pus = wrist; adj. - met'acar'pal.
metaph'ysis - G. meta = after, and phys'is = growth; hence, the end of the shaft of a bone alongside the epiphysial or growth cartilage; adj. - metaphysi'al.
met'atar'sus - G. meta = after, and tarsos = ankle; hence, the bones beyond the tarsus. adj. - met'atar'sal.
metop'ic - adj. G. met'opon = forehead.
min'imus - L. = smallest.
mio'sis - G. meio'sis = lessening; hence, pupillary constriction; adj. - miot'ic.
modal'ity - L. mo'dus = mode; hence, a form of sensation - e.g. touch, pain, sight.
modi'olus - L. a cylindrical borer with a serrated edge; hence, like a screw; the central stem of the bony cochlea.
mo'lar - adj. L. mo'la = mill.
mons - L. = mountain; mons pubis, the soft tissue bulge over the female pubes.
morphol'ogy - G. mor'phos = form, and log'os = word or relation; hence, study of pattern of structure; adj. - morpholog'ical.
multif'idus- L. mul'tus = much, and fin'dere - to split.
musc'le - L. mus'culus, diminutive of G. mus = mouse, the body and head of which represent the main belly of a muscle, and the tail, the tendon.
mydri'asis - G. = dilatation of the pupil
my'elin - G. my'elos = marrow; hence, white fatty sheath of an axis cylinder; adj. - my'elinat'ed.
my'lohy'oid - G. my'lo = molar, and hyoei'des = U-shaped.
my'ocar'dium - G. mys = muscle, and kar'dia = heart, adj. - my'ocar'dial.
my'otome - G. mys = muscle, and tome = a cutting or division; hence, a group of muscles innervated by a single spinal segment.

N (n)

na'ris - L. = nostril (plural - na'res).
na'sal - adj. L. na'sus = nose; hence, pertaining to the nose.
na'tal - adj. L. na'tus = born; hence, relating to birth.
nates - pl. of L. natis = buttocks, clunes.
navic'ular - adj. L. navic'ula = a little ship (cf. naval); hence, the tarsal bone which is concave posteriorly, resembling a boat.
ne'o- - G. prefix - ne'os = new.
ne'ona'tal - adj. G. ne'os = new, and L. na'tos = born; hence, new-born.
ne'opal'lium - G. ne'os = new, and pal'lium - L. = cloak; hence, the cerebral cortex which developed more recently than the archipallium or olfactory cortex.
nerve - L. ner'vus = tendon; later reserved for a peripheral bundle of fibres which conduct impulses from or to the central nervous system.
neu'ral - adj. G. neu'ron = nerve.
neuro'glia - G. neu'ron = nerve, and glo'ia = glue; hence, the connective tissue of the central nervous system; adj. - neurogli'al.
neu'rohypoph'ysis, or posterior lobe of hypoph'ysis - G. hypo = down, and physis = growth; hence, the posterior part of the hypophysis evaginated inferiorly from the diencephalon, and its stalk.

neu'rolem'ma - G. neu'ron = nerve, and lem'ma = peel or rind; hence, the covering layer of a nerve.
neu'ron - G. = nerve; refers to the nerve cell body, with its axon and dendrites; adj. - neuro'nal.
nor'ma - L. = pattern or rule, or aspect; adj. normal - according to rule.
notch - an indentation in the margin of a structure. Etymology uncertain.
no'tochord - G. no'tos = back, and chor'de = cord; hence, the primitive axial skeleton around which the vertebrae develop, parts persisting in the nuclei pulposi.
nu'cha - Fr. nuque = nape or back of the neck; adj. - nu'chal.
nu'cleus - L. = kernel or nut; may refer to the vital centre of a cell body, or to a cluster of neuron cells in the C.N.S.; adj. - nu'clear.

O (o)

o'bex - L. = barrier; hence, the coronal fold of ependyma over the lower angle of the 4th ventricle.
oblique' - adj. L. obliq'uus; slanting, or deviating from the perpendicular or the horizontal.
ob'longa'ta - L. oblong'us = oblong; medulla oblongata.
ob'turator - L. ob'tura'tus = stopped up; whence, a structure which closes a hole.
oc'ciput - L. ob- = prominent (cf. ob-vious), and caput = head; hence, the prominent convexity of the back of the head; adj. - occi'pital.
occlu'sion - L. occlu'sum = closed up; hence, apposition of reciprocal teeth, or the blocking of any tubular structure; adj. - occlu'sal.
oesoph'agus - G. = gullet (passage from pharynx to stomach); adj. - oesophage'al.
olec'ranon - G. ol'ene = ulna, and kranion = upper part of head; hence, the upper end of the ulna.
olfact'ory - adj. L. olfac'to = smell.
ol'ive - L. ol'iva - the oval fruit of the olive tree; oval eminence on medulla oblongata; adj. - ol'ivaryi.
omen'tum - L. = apron; adj. - omen'tal.
o'mohy'oid - G. o'mos = shoulder; hence, a muscle attached to the scapula and hyoid.
oper'culum - L. lid or cover; hence, oper'culum in'sulae, the cerebral cortex covering and hiding the insula (the 5th lobe of cerebral cortex).
ophthal'mic - adj. G. ophthal'mos = eye.
oppose' - L. oppos'itum = put against; hence, to resist or place in contact with, and opposition - the action of opposing.
op'tic - adj. G. op'tos = seen; hence, pertaining to sight.
o'ra serra'ta - L. o'ra = margin, and ser'ra = saw; hence, the serrated anterior edge of the functional part of the retina.
or'bit - L. or'bis = circle; the name given to the bony socket in which the eyeball rotates; adj. - or'bital.
or'ifice - L. orific'ium = opening.
os - either L. os = bone; adj. - oss'eous; or L. os = mouth, adj. - o'ral.
oss'icle - l. ossic'ulus, diminutive of os = bone.
os'sify - L. os = bone, and fac'io = make; hence, to form bone; and os'sifica'tion, the process of bone formation.
osteol'ogy - G. os'teon = bone, and log'y = a field of study.
o'tic - adj. G. o'tos = ear.
o'tolith - G. otos = ear, and lith'os = stone; hence, calcareous particles in the utricle and saccule of the membranous labyrinth.
o'vary - L. o'vum = egg; hence, the organ containing ova (the largest cells in the female).
o'vum - L. egg (plural - o'va).

P (p)

pach'ymen'inx - G. pach'ys = thick, and men'inx = membrane; hence, the thick membrane covering the C.N.S., i.e., dura mater.
pal'ate - L. pala'tum = palate, adj. - pala'tal or pal'atine.
pa'leo - G. pal'aios = old; hence, pa'leocerebel'lum, the earliest stage in the evolution of the cerebellum.
pal'lidus - adj. L. = pale.
pal'lium - L. = cloak; hence, the cerebral cortex forming the outer covering of the cerebral hemisphere.
palma - L. palma = palm; adj. palm'ar - L. palmaris.
palpate' - L. palpa're = to touch, and palpa'tus = touched; hence, to examine by feeling, and palpa'tion, such an examination.
pal'pebra - L. = eyelid, probably from palpita're = to flutter.
pampin'iform - adj. L. pampi'nus = tendril.
pan'creas - G. = sweetbread, derived from G. pan = all, and cre'as = flesh; adj. - pancreat'ic.
papil'la - L. = nipple or teat; adj. - papil'lary.
par'aesthe'sia - G. par'a = beside, and aisthe'sia = sensation; hence, abnormal sensation, usually burning or pricking.
pa'rame'trium - G. par'a = beside, and me'tra = womb; hence, the connective tissue alongside the body of the uterus, within the broad lig.
pa'raple'gia - G. par'a = beside, and pleg'e = a stroke; hence, paralysis of the lower limbs.
pa'rare'nal - adj. G. par'a = beside, L. ren = kidney; hence, beside the kidney, e.g., pa'rare'nal fat, the fatty capsule of the kidney.
pa'raster'nal - adj. G. par'a = beside, and ster'non = chest; hence, the pa'raster'nal line is a vertical line about midway between the sternal edge and the midclavicular line.
pa'rasympathet'ic - adj. G. par'a = beside, syn = with, and path'os = feeling; hence, the division of the autonomic nervous system complementary to the sympathetic system.
pa'rathy'roid - adj. G. par'a = beside, and thy'roid; hence, beside the thyroid gland.
pare'sis - G. = relaxation, but has come to mean partial paralysis.
pari'etal - adj. L. parieta'lis, pertaining to par'ies = wall.
paro'tid - adj. G. par'a = beside, and o'tos = of the

ear; hence, beside the ear.
par'ous - adj. L. pa'rio = I bear (children); hence, adj. applied to woman who has borne one or more children (cf. nullip'arous, multip'arous).
pars - L. = part.
patel'la - L. a small pan; adj. - patel'lar.
pec'ten - L. comb.
pec'tinate - adj. (from *pecten*) applied to structures having the appearance of parallel teeth arising from a straight back (mm. pectina'ti), or the sellar appearance of the superior pubic ramus, which may have resembled the body of antique combs.
pec'toral or pectora'lis - adj. L. pectoris = of the front of the chest.
ped'icle - diminutive of L. ped'is = of the foot.
ped'is - L. = of the foot.
pedun'cle - variatioon of pedicle.
pellu'cidum - adj. L. per = through, and lu'cere - to shine; hence, translucent.
pel'vis - L. = basin; adj. - pelvic.
pe'nis - L. = tail; the male organ of copulation.
penna'tus or pen'nate or pin'nate - adj.s. L. pen'na = feather; hence, a muscle whose fibres approach the tendon from one direction is unipennate; from two, bi'pennate, and from more than two, mul'tipen'nate.
per'ianal - adj. G. per'i = around, and L. a'nus = lower opening of alimentary canal.
per'icar'dium - G. per'i = around, and kar'dia = heart; hence, the membranes enclosing the heart.
per'icra'nium - per'i - G. around, and kra'nion = skull; hence, the external periosteum of the skull.
per'ichon'drium - per'i - G. = around, and chon'dros = cartilage; hence, the membrane covering cartilage.
per'ilymph - per'i - G. around, and lymph'a - L. = clear water; hence, the fluid in the bony labyrinth surrounding the membranous labyrinth (and continuous with C.S.F.).
per'ine'um - G. the caudal aspect of the trunk between the thighs, or, the region of the trunk below the pelvic diaphragm; adj. - per'ine'al.
per'iodon'tal - adj. G. per'i = around, and o'dont = tooth.
per'ios'teum - per'i - G. = around, and os'teon = bone; hence, the membrane around a bone.
per'ipher'al - adj. (cf. periphery) - G. per'i = around, and phe're = carry; hence, away from the centre.
per'istal'sis - per'i - G. around, and stel'lein - to constrict; hence, a circular constriction passing as a wave along a tube; adj. - per'istal'tic.
per'itone'um - G. per'itei'no = to stretch around; hence, the membrane stretched around the internal surface of the walls and the external aspect of some of the contents of the abdomen; adj. - per'itone'al.
per'one'al - adj. G. per'one = clasp - see fibula.
pes - L. = foot.
pe'trous or petro'sal - adj. L. petro'sus = rocky.
phal'anx - L. = row of soldiers; hence, one of the small bones of a digit, plural - phal'anges.; adj. - phal'ange'al.
pharynx - G. = throat; adj. - phar'ynge'al.
phil'trum - G. phil'tron - the median sulcus of the upper lip. Derivation doubtful.
phona'tion - G. pho'ne = sound or voice; hence, the production of either.
phren'ic - G. phren = diaphragm or mind; hence, diaphragmatic (cf. schizophrenic)..
pi'a - L. = faithful, hence, the membrane which faithfully follows the contour of the brain and spinal cord.
pi'lus - L. = a hair.
pine'al - adj. L. pin'ea = a pine cone; hence, the pineal gland which is cone-shaped.
pir'iform - adj. L. pi'rum = a pear; hence, pear-shaped.
pi'siform - adj. L. pi'sum = a pea; hence, pea-shaped.
plane - L. pla'nus = flat; hence, a real or imaginary flat surface
plan'ta - L. the sole of the foot; adj. - plan'tar or planta'ris.
platys'ma - G. = flat object; hence, the flat subcutaneous muscle extending from below the clavicle to the mouth.
pleu'ra - G. = a rib. Later used to name the serous membrane lining the chest walls and the lung on each side.
plex'us - L. = a network or plait.
pli'ca - L. plica're = to fold; hence, a fold.
pollex - thumb
pons - L. = bridge; adj. - pon'tine; part of the brain stem.
poplite'us - L. pop'les = the ham or thigh, and sometimes, the knee; adj. poplite'al, referring to the fossa posterior to the knee or its contents.
por'us - L. a pore or foramen; hence, the openings of the acoustic meatuses.
por'ta - L. = a gate, also L. porta're = to carry; hence, the portal system carries venous blood from the alimentary tract to the por'ta hep'atis; adj. - port'al.
posterior - adj. L. post = behind (in place or time).
pos'ture - L. pos'itus = placed; hence, the position of the body as a whole at a given momment, e.g. erect, recumbent, prone, supine, sitting, kneeling.
precun'eus - L. pre = before, and cun'eus = wedge; hence, the parietal lobule anterior to the cuneus.
prep'uce - L. praepu'tium = foreskin (of penis or clitoris).
proce'rus - L. slender, elongated; hence, the vertical slip of muscle between themedial part of frontalis and the root of the nose.
pro'cess, proces'sus - L. going forwards, used to indicate growing out, i.e., an outgrowth, usually of bone, e.g., the zygomatic process of the temporal.
prom'ontory - L. promontor'ium = a headland, i.e., part of land jutting into the sea - used for a bony prominence.
prone - L. prona'tus = bent forwards; hence,

recumbent face-down posture; hence, to pro'nate = to turn the hand so that the palm faces posteriorly.

pro'priocep'tive - L. prop'rius = one's own, and cap'tum = taken; hence, sensory impulses received by the joints and muscles within one's own body.

prosec'tor - L. pro = before, and sec'tum = cut. One who prepares a dissection for demonstration.

pro'senceph'alon - pro - L. = in front, and enkephalos - G. brain; hence, the part of the brain rostral to the midbrain.

pros'tate - G. pro = before, and L. = sta'tum = stood; hence, something which stands before - the prostate stands before the urinary bladder.

protract' - L. protract'us = drawn out; hence, to put forwards (e.g., shoulder or mandible). Protrac'tion - the act of protracting.

protrude' - L. protru'do = thrust forwards, e.g. the tongue; protru'sion - the act of protruding.

protu'berance - L. protu'bero = I bulge out; hence, a bulging bony feature (see tuber).

prox'imal - adj. L. prox'ime = nearest; hence, nearer to the root of a limb.

pso'as - G. = loin.

pter'ion - G. pter'on = wing; hence, the region where the tip of the greater wing of the sphenoid meets or is close to the parietal, separating the frontal from the squamous temporal; alternatively the region where these 4 bones meet.

pter'ygoid - adj. G. pter'yx = wing, and oid = shape; hence, wing-shaped.

pto'sis - G. = fall; hence, drooping of an eyelid, or descent of an internal organ.

pu'berty - L. pu'ber = adult; hence, the time when hair appears in the pu'bic region - i.e., near the pu'bis - as a secondary sexual characteristic.

puden'dal - adj. L. puden'dus = shameful; hence, pertaining to the external genitalia.

pul'monary - adj. L. pul'mo = lung.

pulp - L. pul'pa = a soft part of the body or tooth.

pulvinar - L. pulvinus = rounded cushion; the posterior end of the thalamus.

pu'pil - L. pupil'la = the central black orifice in the iris; adj. - pupil'lary.

puta'men - L. = peel, husk or shell of fruit or seed (the external part of the lentiform nucleus).

py'elogram - G. py'elos = basin, and gramma =diagram; hence, radiograph of the renal pelvis (and usually of the ureter) after filling with contrast medium.

pylor'us - G. = gate-keeper; hence, the part of the pyloric canal containing the sphincter, which guards the opening into the duodenum; adj. - pylor'ic.

pyr'amid - G. pyr'amis = a pyramid (solid with 3- or more-sided base, and flat sides meeting at the apex), adj. - pyram'idal.

Q (q)

quadra'tus - L. = square or rectangular.

quad'riceps - L. quad'ri - pertaining to 4, and cap'ut = head; hence, a 4-headed muscle.

R (r)

ra'dia'tion - L. radia'tus = radiant; hence, divergence from a common centre (cf. radius).

ra'dius - L. = spoke of a wheel, which rotates around the hub; hence, the lateral bone of the forearm, which rotates (though around an almost vertical axis); adj. - ra'dial.

ra'dix - L. = root.

ram'ify - L. ra'mus = a branch; and fac'ere = to make; hence, to branch.

ra'mus - L. = branch; hence, a branch of a nerve.

ra'phe - G. a seam; hence, the line of junction of the edges of 2 muscles or areas of skin.

re'cess - L. reces'sus = a secluded area or pocket; hence, a small cavity set apart from a main cavity.

rec'tum - adj. L. rec'tus = straight. (The rectum was named in animals where it is straight - which it is not in Man).

reflect' - L. reflec'to = to bend back; hence, reflection = a turning or folding back.

re'flex - an involuntary response - muscular or secretory - to a stimulus mediated by the C.N.S.

re'nal - adj. L. ren = kidney.

re'te - L. a net; hence, a network of veins or tubules.

retic'ulum - L. diminutive of re'te; adj. - retic'ular.

ret'ina - derivation uncertain - the innermost of the 3 layers of the eyeball.

retinac'ulum L. = a tether; hence, a thickened band of deep fascia which retains tendons or the patella.

retract' - L. re = back, and tract'um = pulled; hence, to pull something back, and retrac'tion - the act of retracting.

ret'ro - prefix - L. = backwards.

ret'roflex'ion - ret'ro - L. backwards, and flex'ion = bent; hence, the position of being bent backwards, applied to the angulation of the body of the uterus on the cervix.

ret'rover'sion - ret'ro - L. backwards, and ver'sion = turned; hence, the position of being turned backwards, applied to the angulation of the cervix uteri on the vagina.

rhi'nenceph'alon - rhin'ion, G. = nostril, and enkeph'alos = brain; hence, the part of the brain concerned with smell (relatively large in lower animals).

rhom'benceph'alon - rhom'bos - G. = rhom'boid, and enkeph'alos = brain; hence, the hind-brain - the medulla oblongata, pons and cerebellum, which enclose the rhom'boid fos'sa (the floor of the 4th ventricle).

ri'ma - L. = chink; hence, e.g., ri'ma palpebra'rum = the chink between the free edges of the eyelids.

risor'ius - L. ri'sor = scoffer; hence, m. risor'ius is the facial muscle which expresses laughter by drawing the corner of the mouth laterally.

rostral - see *rostrum*.

ros'trum - L. beak, which decorated the Roman orator's platform; hence, a platform or beak-like structure; adj. - ros'tral, implying nearness to the

ros'trum of corpus callosum.
rotate' - L. ro'ta = wheel; hence, to turn, and rota'tion, the act of turning.
ru'ga - L. = a wrinkle.

S (s).

sac - L. sac'cus = a sack.
sac'cule - L. sac'culus, diminutive of sac'cus.
sa'crum - L. sac'er = sacred (probably considered so because of its size).
sag'ittal - adj. L. sag'itta = arrow, because the sag'ittal suture is notched posteriorly, like an arrow, by the lambdoid sutures.
sal'ivary - adj. L. sali'va = spit.
sal'pinx - G. = trumpet; hence, the uterine or auditory tube, each of which is trumpet-shaped.
saph'enous - adj. G. saphe'nes = obviously visible. The saphenous vv. become very apparent when varicose.
sartor'ius - L. = tailor; hence, sartorius mm., which produce the posture in which tailors once worked, squatting on the floor.
sca'la (pl. sca'lae) - L. = stairs; hence the parallel spiral passages which wind up to, or down from, the cupula of the bony cochlea.
sca'lene, scale'nus - adj. G. skale'nos = uneven, hence a triangle with unequal sides, an apt description of the shape of scalenus anterior and scalenus medius mm.
sca'phoid - adj. G. ska'phe = skiff; hence the carpal which is hollowed out on its distal surface for the head of the capitate; also the fossa occupied by tensor veli palatini m.
scap'ula - G. skap'to = I dig, because of the resemblance to a spade.
sciat'ic - adj. G. isch'ion = hip-joint. Ischiad'ikos meant pertaining to the ischium or hip - later changed to sciat'ic. (The ischium earns its name because it forms > 2/5 of the acetabulum, whereas the ilium contributes < 2/5, and the pubis only 1/5). The sciatic nerve lies on the ischium.
scle'ra - G. skle'ros = hard; hence the tough, outer layer of the eyeball; adj. - scle'ral.
scro'tum - possibly derived from L. scor'teus = leather; adj. - scro'tal.
secrete' - L. secre'tus = separated; hence, to produce a chemical substance by glandular activity - adj. secretory; noun, secretion.
sel'la - L. = saddle; adj. - sellar, sel'la tur'cica = Turkish saddle.
se'men - L. = seed; adj. - sem'inal (seminal vesicle).
sem'iluna'ris - adj. L. sem'i = half, and lu'na = moon; hence, having a half-moon shape.
sem'imembrano'sus - adj. L. sem'i = half, and membra'na = membrane; hence, the ham muscle of which the upper half is membranous.
sem'itendino'sus - adj. L. semi' = half, and ten'do = I stretch; hence, the ham muscle of which the lower half is tendinous.
sep'tum - L. saep'tum = fenced in; hence, a dividing fence or partition.
serratus - adj. L. = notched like the edge of a saw (serrate).
sesamoid - adj. G. sesamo'des, -oid = like; like grains of sesame, hence, small bone in tendon at site of friction.
sial'ogram - G. si'alon = saliva, and gram'ma = a diagram; hence, a radiograph of a salivary duct.
sig'moid - adj. G. sig'ma, the form used at the end of a word having an S-shape; hence, S-shaped.
sin'ister - adj. L. = left-sided.
si'nus - L. = a hollow or space which may contain air, venous or arterial blood, lymph or serous fluid; adj. sinus'oid.
sole - the lower surface of the foot - see sole'us.
sole'us - adj. L. sole'a = flatfish or sandal; hence m. sole'us which does not enter the sole of the foot, but resembles the fish.
somat'ic - adj. G. so'ma = the body; hence, pertaining to the body frame but not to its viscera.
spasm - G. spas'mos = an involuntary contraction of a muscle; adj. - spastic, or spasmodic.
sperm'a - G. = seed or semen, adj. spermat'ic.
sphe'noid - adj. G. sphen = wedge, and -oeides = shape; hence the unpaired bone which is wedged into the base of the skull between the unpaired frontal and occipital.
sphinc'ter - G. sphink'ter = a tight binder; hence, a circular muscle which closes an orifice; adj. - sphincter'ic.
spine - L. spi'na = a thorn; hence, a sharp process, or a lay term for the vertebral column; adj. spinous, spinal.
splanchnic - adj. G. splanchnon = a viscus or internal organ; hence pertaining to viscera.
spleen - L. splen; hence; adj. - splen'ic.
sple'nium - G. splen'ion = a bandage. Hence, splen'ius capi'tis m., with its finely-woven fibres and its quarter-spiral twist from a coronal to a sagittal plane. The splenium of corpus callosum resembles a partly rolled bandage.
spongiosum - adj. G. spon'gia = a sponge.
squa'ma - L. = a scale (as of fish or reptile); adj. - squa'mous.
sta'pes - L. = stirrup; adj. - stape'dial, stape'dius.
stel'late - adj. L. stel'la = star.
ster'num - G. ster'non = chest or breast; adj. sternal.
stom'ach - G. stoma'chos = gullet or oesophagus, later applied to the wider part of the digestive tract just below the diaphragm; adj. - gas'tric.
strabis'mus - G. strabis'mos = squinting; hence, inability to focus both eyes on a given point.
stra'tum - L. = a covering sheet, or layer.
stri'a - L. = furrow, applied to a streak or stripe.
stria'tum - adj. L. stria'tus = furrowed; hence, cor'pus stria'tum, the caudate and lentiform nuclei connected by grey strands which traverse the internal capsule, giving the strands a striated appearance.
stro'ma - G. = bed or mattress, deep to the covers; hence, the supporting framework of an organ, as distinct from its special parenchyma.
sty'loid - adj. G. sty'los = an instrument for writing, and -oeid'es = like; hence a pen- or pencil-like

structure.
suc'cus - L. = juice (s. entericus, the secretion of the small intestine).
sul'cus - L. = a groove.
su'percil'iary - adj. L. su'per = above, and cil'ia = eyelid; hence, pertaining to the eyebrow.
su'perfic'ial - adj. L. su'per = above, and fa'cies = surface; hence, nearer the surface.
supe'rior - adj., comparative of L. su'perus = above.
su'pine - adj. L. supi'nus, recumbent on the back. Hence, also, the position of the hand with the dorsum facing posteriorly.
su'pina'tion - the act of turning the back of the hand to face posteriorly; verb - su'pinate.
su'pra - L. prefix = superior to.
sural - adj. L. sura = the calf.
sustentac'ulum - L. = a support, which sustains; s. tali - the ledge on the calcaneus supporting part of the talus.
su'ture - L. su'tura = a seam; the fibrous joints between cranial bones.
sympathet'ic - G. syn = with, and pathos = feeling; hence, the peripheral part of the autonomic nervous system which arises in the thoracolumbar region of the spinal cord and communicates with other nerves.
sym'physis - G. syn = with, and phy'sis = growth; hence a joint where union between the bones is by fibrocartilage - used for median joints. (Symphysis of the mandible is exceptional, the 2 halves fusing before the age of 2).
syn'apse - G. syn = with, and ap'tein = to join; hence, the zone through which an impulse passes from one neuron to another.
syn'chondro'sis - G. syn = with, and chon'dros = cartilage; hence, the union of 2 bones by cartilage.
syndesmosis - G. syn = with, and desmos = a band; hence, the union of 2 bones by fibrous tissue.
syn'drome - G. syn = with, and drom'os = running; hence, a group of signs and symptoms which is characteristic of a certain pathology.
syner'gist - G. syn = with, and er'gon = work; hence a muscle which cooperates with others in producing a given movement.
synovia - G. syn = with, and ovum = egg; hence the fluid in freely movable joints resembling egg-white; adj. syno'vial.
sys'tole - G. = contraction; hence the contraction of cardiac muscle.

T (t)

tae'nia (te'nia) - L. a tape or ribbon.
ta'lus - L. = ankle-bone; hence, the tortoise-shaped tarsal of the talocrural (ankle) joint.
tape'tum - L. a carpet or coverlet; hence the roof of the posterior horn of the lateral ventricle.
tar'sus - G. tarsos = a flat surface; hence the flat part of the foot, and later, the bones of the foot posterior to the metatarsals, adj. tarsal.
tec'tum - L. = roof; hence the roof of the midbrain.
teg'men - L. = covering (cf. integument = the skin).
tegmen'tum - L. = covering.
te'la - L. a web; e.g., a fold of pia mater containing a choroid plexus.
telenceph'alon - G. telos = end, and enkephalos = brain; hence the rostral part of the developing brain. (With the diencephalon, it makes up the prosencephalon).
tem'poral - L. tempus = time; hence, the temporal area of the scalp, where grey hair first appears, marking the progress of ageing.
ten'don - L. tendo = I stretch out.
ten'sor - L. tensus = stretched; hence a muscle which produces tension.
tentor'ium - L. = tent; tentorium cerebelli.
te'res - L. = rounded, cylindrical.
tes'tis, tes'ticle - L. a testis, the male gonad.
thal'amus - G. = bedroom - derivation rather obscure, though the posterior end of the thalamus is rounded and named pulvinar = cushion.
the'nar - G. = palm of hand; hence, the ball of the thumb.
tho'rax - G. = the chest, adj. thora'cic.
throm'bus - G. = a clot.
thy'mus - G. = sweetbread.
thy'roid - G. thyreos = shield, and -oeides = shape; hence, shaped like a shield (which shields the glottis).
tib'ia - L. = the shin-bone, adj. tib'ial.
ton'sil - L. tonsilla = tonsil (e.g., palatine t.).
to'rus - L. = a bulge.
trabec'ula - diminutive of L. trabs = a beam; hence the supporting fibres of a structure.
trache'a - G. tracheia = rough, referring to its corrugations.
tract - L. tractus = an elongated strand of wool or dough; hence a pathway for nerve fibres.
tra'gus - L. = goat, because of the beard-like tuft of hair on its internal aspect.
trans'verse - perpendicular to the long axis.
trape'zium - G. trape'zion = a trapezium - a quadrilateral with 2 sides parallel; hence, trapezius m., the diamond-shape of both trapezii mm. together.
trap'ezoid - resembling a trapezium.
tri'ceps - L. tres = 3, and cap'ut = head; hence a 3-headed muscle.
trigem'inal - L. trigem'inus = triplets; hence, cranial n. V, with 3 large divisions.
tri'gone - L. trigo'num = a triangle.
trique'tral - L. trique'trus = 3-cornered.
triti'cea - L. tri'ticum = a grain of wheat; hence, the tiny cartilage in the lateral thyrohyoid lig.
trochan'ter - G. = a runner; hence, the bony landmark, the greater trochanter, which moves so obviously in running.
troch'lea - G. trochi'lia = a pulley.
trun'cus - L. = trunk (of a tree).
tu'ber - see tuberosity.
tu'bercle, tuber'culum - L. diminutive of tuber, a small prominence, usually bony.tuberos'ity - L. tu'ber = a swelling or lump, usually large and rough.
tuberos'ity - L. tuberositas = lumpy

tu'nica - L. shirt; hence a covering.
tym'panum - L. = a drum.

U (u)

ul'na - L. = elbow or arm; hence, the medial bone of the forearm.
umbili'cus - L. = the navel.
um'bo - L. = the boss on the centre of a shield, umbo of tympanic membrane.
un'cus - L. = hook; adj. - uncinate.
un'gual - pertaining to L. unguis = finger-nail.
ure'ter - G. oureter = passage from kidney to bladder.
ure'thra - G. ourethra = passage from bladder to exterior.
u'terus - L. = womb.
u'tricle - diminutive of uterus.
u'vula - diminutive of L. u'va = grape.

V (v)

vagi'na - L. = sheath; hence, invagina'tion is the acquisition of a sheath by pushing inwards into a membrane, and evagina'tion is similar but produced by pushing outwards.
va'gus - L. = wandering; hence, cranial n. X, which leaves the head and neck to traverse the thorax and upper part of the abdomen.
val'late - L. valla'tus = walled; hence, the large papillae on the tongue which are depressed below the surface and are surrounded by a groove which is itself bounded by a wall.
vallec'ula - diminutive of L. val'lis = a fossa.
valve - L. val'va = the segment of a folding-door.
val'vula - diminutive of L. valva.
vas - L. = vessel (plural = va'sa).
vas'cular - L. vas'culum, diminutive of vas; hence, pertaining to blood vessels.
vein - L. ve'na; adj. ve'nous.
ve'lum - L. = curtain; veli = of a curtain..
ven'ter - L. = belly; hence, ven'tral, pertaining to the belly side.
ven'tricle - diminutive of L. ven'ter, a small belly.
ver'miform - L. ver'mis = a worm, and for'ma = shape; hence, worm-shaped.
ver'mis - L. = worm; hence, the segmented median part of the cerebellum.
ver'tebra - L. ver'to = I turn; hence, one of the movable bones of the backbone which seems to be shaped for rotation.
ver'tex - L. = summit; hence the highest point on the skull.
ver'tical - perpendicular (at a right angle) to the horizontal.
ve'sica - L. = bladder; adj. vesi'cal.
vesic'ula - diminutive of ve''sica; sem'inal ve'sicle.
ves'tibule - L. vestib'ulum = entrance hall.
vibris'sa - L. vibra're = to vibrate; hence, the hairs in the nasal vestibule which vibrate in the current of air.
vil'lus - L. a hair; hence, a vascular, hair-like process, usually projecting from a mucous surface.
vin'cula - L. = fetters (singular: vin'culum); hence, the delicate vascular synovial bands passing to a tendon in the digits.
vis'cus - L. = an internal organ (plural, vis'cera), adj. vis'ceral.
vit'reous - L. vit'reus = glassy.
vo'mer - L. = plough-share; hence, the bone of the nasal septum which is split in two at its upper edge.
vortico'sae - L. vor'tex = whirl; hence the whirl-like arrangement of the 4 vv. vortico'sae leaving the eyeball.
vul'va - L. = the external female genitalia.

X (x)

xiph'oid - G. xiph'os = a sword, and -oeides = shape; hence, sword-shaped.

Z (z)

zo'na - L. = a belt; hence, a circular band.
zon'ule - diminutive of zona.
zygomat'ic - G. zy'gon = yoke; hence, the bone joining the maxillary, frontal, temporal and sphenoid bones.
zy'gote - G. zy'gon = yoke; hence the fusion of the male and female gamete

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Additions by Dr. B. Freeman (2002)
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