

# Assessment of Diesse Ves-matic automated system for measuring erythrocyte sedimentation rate

M Caswell, J Stuart

## Abstract

**Measurement of the erythrocyte sedimentation rate (ESR) using a closed tube system reduces the biohazard risk to laboratory staff. The Diesse Ves-matic system offers manual or vacuum collection of blood into plastic tubes, automated mixing of the sample, and automated reading of the end point after 20 minutes of sedimentation. This system was compared with the 1977 Westergren ESR method of the International Council for Standardization in Haematology (ICSH) and with the 1988 ICSH undiluted ESR method. Manually collected Ves-matic samples showed good agreement with ICSH values, although there was a tendency to false low results at low ESR values which may represent dilution of plasma protein with excess citrate. Vacuum collected Ves-matic samples also showed good agreement with ICSH values, although there was a tendency to false high results which may reflect a change in the blood: citrate ratio caused by loss of anticoagulant diluent or vacuum from plastic tubes during storage. The Diesse Ves-matic system incorporates several improvements over previous technology and offers a safer, quicker, and more standardised ESR.**

The erythrocyte sedimentation rate (ESR)<sup>1,2</sup> remains the most frequently used laboratory test of the acute phase inflammatory response. Although the ESR lacks specificity, it can be effective in determining prognosis, as in Hodgkin's disease,<sup>3</sup> or prostatic cancer,<sup>4</sup> and for monitoring disease activity, as in rheumatoid arthritis.<sup>5</sup> The ESR is influenced by acute phase proteins and haematocrit, both of which are changed in these disorders and have an additive effect on the sedimentation rate, thereby increasing test efficacy.

The ESR method selected by the International Council for Standardization in Haematology (ICSH)<sup>6</sup> is based on that of Westergren.<sup>2</sup> Subsequent ICSH guidelines<sup>7</sup> allow for the use of alternative ESR techniques, provided that comparability with the Westergren ESR is achieved.

Increased awareness of biohazard risk to laboratory staff has led to safer methods for performing the ESR, such as the use of unopened blood collection tubes.<sup>8</sup> Vacuum

controlled aspiration of the sample also reduces operator contact with blood and can provide correct dilution with sodium citrate anticoagulant which is important for accuracy.<sup>2,8</sup> Automated mixing of the blood sample is also beneficial as the number and size of red cell aggregates at the beginning of the test influence the result.

We evaluated the Diesse Ves-matic ESR system which can be performed using manually filled tubes (Ves-tec) or vacuum aspiration tubes (Vacu-tec).<sup>9-12</sup> This system provides automated mixing of the diluted blood and gives an end point after 20 minutes of sedimentation which is claimed to be comparable with the Westergren ESR value after 60 minutes of sedimentation.

## Methods

The Ves-matic system (Diesse Diagnostica Senese Srl, 5305 Monteriggioni (SI), Italy) comprises 90 mm long plastic tubes containing 0.35 ml sodium citrate (105 mmol/l) anticoagulant-diluent. Both manually and vacuum filled tubes are rectangular in cross-section with internal dimensions which taper from 8.65 × 3.3 mm at the top to 7.7 × 2.4 mm at the base. After being filled with 1.1 ml blood to an intended height of 60 mm the tubes are placed in individual holders in a measuring device which maintains the tubes at an angle of 18° to the vertical. The blood samples are mixed by rotation for a standardised period and a photoelectric cell then passes up the outside of each tube to record the height of the column of red cells at which light transmission occurs. After 20 minutes of sedimentation, timed electronically, the new level at which light passes through the column is recorded and the decrease in height is corrected mathematically to give a result which is stated to be comparable with the Westergren ESR at one hour. Sedimentation can be continued for a further 20 minutes to derive a value for the Westergren ESR at two hours, but we did not study this value.

Two measuring devices are available: the Ves-matic Junior has capacity for 20 samples in a circular carousel and mixes them by rotation of the carousel for five minutes. The Ves-matic Senior holds 60 samples in four rows which are mixed for two minutes by rotation. Both devices monitor ambient temperature and the ESR result obtained can be corrected to that expected if the test had been

Department of  
Haematology, Medical  
School, University of  
Birmingham,  
Birmingham B15 2TT  
M Caswell  
J Stuart

Correspondence to:  
Professor J Stuart

Accepted for publication  
22 May 1991

performed at 18°C. Both instruments will print a hard copy of the results and have the facility to be connected to a laboratory computer via an RS232 port for direct transfer of results. The Ves-matic Senior has an integral computer which displays graphically the sedimentation curve for each sample by scanning the tube every four minutes and interpolating the curve between the measured points.

Blood was taken from 252 patients with an inflammatory response (infection, lymphoma, after surgery, rheumatoid arthritis). Venous specimens were collected using vacuum aspiration tubes containing 0.34 M K<sub>3</sub>EDTA (0.054 ml per 4.5 ml blood; Becton Dickinson Vacutainer Systems, Oxford) and transferred manually to 90 mm long Diesse Ves-tec tubes containing citrate; 206 of these patients also had blood collected by vacuum directly into Vacu-tec tubes containing citrate. The original 252 EDTA samples were also diluted 4:1 with sodium citrate (109 mmol/l) and used to perform an ICSH Westergren ESR using 300 mm long glass pipettes conforming to British Standard 2554 (Travenol, Stone, Staffordshire). This Westergren ESR was performed according to the standardised selected method of the ICSH.<sup>6</sup> The ICSH also recommends that, for comparability between methods, a second ESR be performed with Westergren pipettes, but using EDTA anticoagulated blood without added citrate to give a Westergren ESR value that is independent of dilution.<sup>7</sup> This ICSH undiluted ESR was performed on 99 of the 252 samples with an original haematocrit in the range 0.30–0.36 l/l and the result was corrected for lack of dilution using the ICSH<sup>7</sup> formula: (undiluted ESR × 0.86) – 12. Any new ESR system under evaluation should give results within 12 mm/h of the ICSH undiluted ESR.<sup>7</sup> Thus the Ves-matic system was compared with both the 1977 (ICSH Westergren) and 1988 (ICSH undiluted) ESR methods recommended by the ICSH.

The stability of blood in Ves-matic tubes was assessed by storing most of the 252 samples for 24 hours at 4°C. The samples were then allowed to return to room temperature before retesting.

Samples of Vacu-tec tubes from two batches were examined to determine the volume of citrate anticoagulant present and the volume of blood aspirated. Seventy six tubes were examined three to four months after manufacture and 20 tubes 10–11 months after

Table 1 Coefficient of variation (CV) for 10 replicate ESR measurements on each of eight patients using Junior and Senior Ves-matic instruments

	Mean ESR (mm/h)	CV (%)
Junior Ves-matic:		
	5.4	15.6
	16.4	7.2
	25.6	4.2
	29.7	4.2
	42.7	3.1
Senior Ves-matic:		
	7.9	9.3
	18.7	5.1
	48.2	2.4

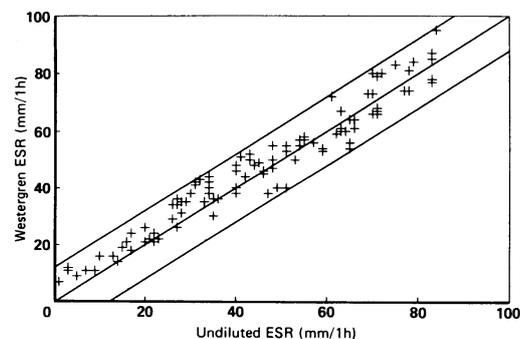


Figure 1 Comparability between the ICSH undiluted ESR and the ICSH Westergren ESR performed on blood diluted with citrate. Lines represent equality  $\pm 12$  mm/h ( $n = 99$ ).

manufacture; the recommended expiry date for Vacu-tec tubes is 12 months after manufacture. The 96 tubes were weighed before use. After venepuncture the height of the column of blood aspirated was marked and, after measurement of the ESR, the tubes were emptied, washed, and dried. The tubes were reweighed and the difference in weight was taken as the original volume of sodium citrate anticoagulant. The weight of distilled water required to fill the tube to the marked level was also determined and this was used to calculate the actual volume of blood aspirated. The volume of distilled water required to fill each tube to the 60 mm line was measured where this line was different from the level to which the blood had been aspirated.

## Results

Precision of the Diesse Ves-matic system was determined on 10 Vacu-tec samples taken by one venepuncture from each of eight patients with an ESR value in the range 5–48 mm/h. Results for the Junior and Senior Ves-matic instruments are given in table 1.

The ICSH Westergren ESR, using blood diluted with citrate, agreed closely with the ICSH undiluted ESR value (fig 1). Agreement between the results obtained for the ICSH Westergren ESR and the four Ves-matic systems is shown in figs 2, 3, 4 and 5. For each blood sample, the mean of the Ves-matic result and the corresponding Westergren result was plotted against the difference between the two

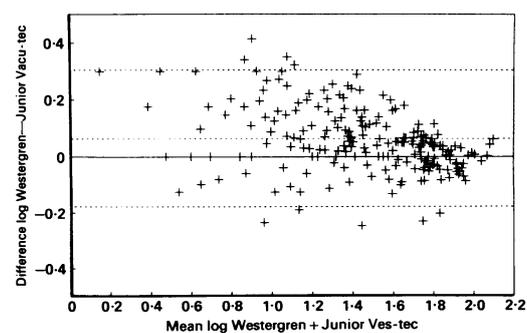
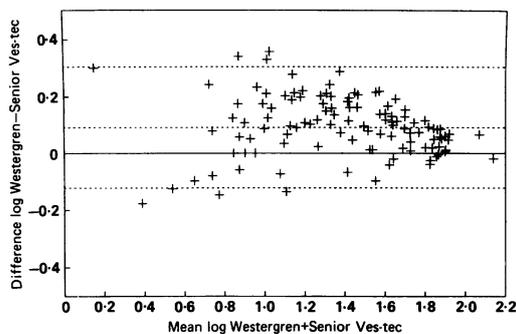
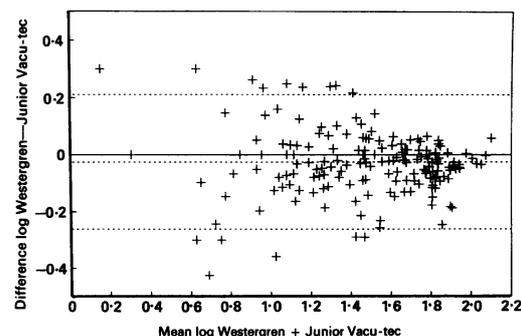


Figure 2 Relation between mean of log Westergren and Junior Ves-tec results and their difference (Westergren result minus Ves-tec). Interrupted lines represent mean difference  $\pm 2SD$  (14.3 mm/h) for 252 samples.

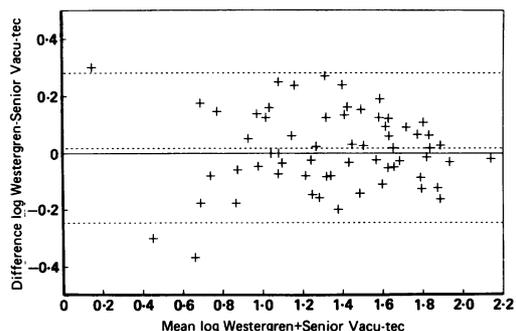
**Figure 3**  
Relation between mean of log Westergren and Senior Ves-tec results and their difference (Westergren result minus Ves-tec). Interrupted lines represent mean difference  $\pm 2SD$  (12 mm/1h) for 128 samples.



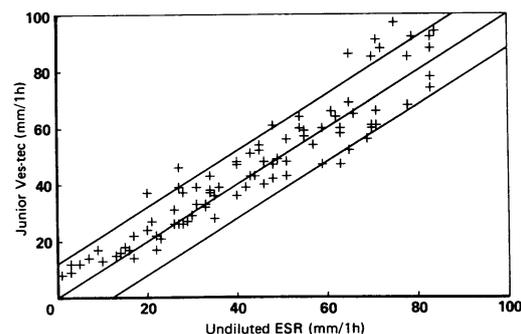
**Figure 4**  
Relation between mean of log Westergren and Junior Vacu-tec results and their difference (Westergren result minus Vacu-tec). Interrupted lines represent mean difference  $\pm 2SD$  (16 mm/1h) for 206 samples.



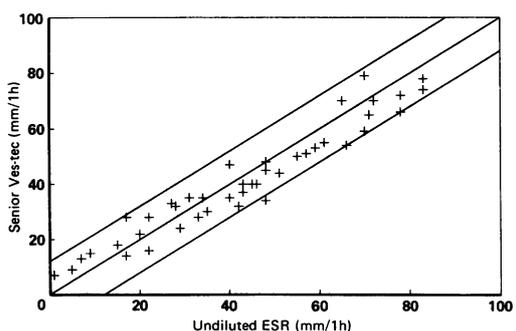
**Figure 5**  
Relation between mean of log Westergren and Senior Vacu-tec results and their difference (Westergren result minus Vacu-tec). Interrupted lines represent mean difference  $\pm 2SD$  (16.2 mm/1h) for 76 samples.



**Figure 6**  
Comparability between the ICSH undiluted ESR and the Junior Ves-tec ESR. Lines represent equality  $\pm 12$  mm/1h (n = 91).



**Figure 7** Comparability between the ICSH undiluted ESR and the Senior Ves-tec ESR. Lines represent equality  $\pm 12$  mm/1h (n = 43).



results. This is a more sensitive method than the correlation coefficient for determining agreement between two methods.<sup>13</sup> As the difference between the results is determined from the Westergren ESR result minus the Ves-matic result, a negative value for the difference indicates a false high result for the Ves-matic ESR compared with the Westergren ESR. Conversely, a positive result indicates a false low Ves-matic ESR result. As ESR results do not conform to a normal (Gaussian) distribution, decimal logarithmic values were used. Inclusion of the range  $\pm 2$  SD, with the corresponding value in mm/1 h gives an indication of the comparability of the two methods in clinical terms. Agreement between the results obtained for the ICSH undiluted ESR and the four Ves-matic systems is shown in figs 6, 7, 8 and 9. Smaller numbers occur as Vacu-tec samples were unavailable for some patients.

Results for the Junior and Senior Ves-tec (manual aspiration) systems showed good agreement (2 SD equivalent to 12–14 mm/1 h difference) with the ICSH Westergren ESR, although there was a tendency to false low results particularly at low ESR values (figs 2 and 3). Both systems agreed closely, within the ICSH limits of  $\pm 12$  mm/1 h, with the ICSH undiluted ESR result (figs 6 and 7). Junior Ves-tec results showed 13% of 91 values outside the 12 mm/1 h range (fig 6) and Senior Ves-tec results showed 2% of 43 values outside the range (fig 7).

The Junior and Senior Vacu-tec (vacuum aspiration) systems also agreed well (2 SD equivalent to 16 mm/1 h difference) with the ICSH Westergren (figs 4 and 5) and ICSH undiluted (figs 8 and 9) ESRs but showed a tendency to false high values.

The mean volume of citrate in 76 Vacu-tec tubes examined three to four months after manufacture was 0.354 ml (95% CI 0.351 to 0.357) and the volume of blood aspirated was 0.980 ml (95% CI 0.969 to 0.992). In the 20 Vacu-tec tubes examined 10–11 months after manufacture, however, the mean volume of citrate was 0.326 ml (95% CI 0.323 to 0.329) and the mean volume of blood aspirated 0.902 ml (95% CI 0.885 to 0.918). These decreased volumes, however, balanced one other, resulting in the same ratio of blood to citrate diluent (2.77:1).

Storage of blood samples for 24 hours at 4°C gave slightly (mean 5 mm) low ESR values by all methods (table 2).

**Discussion**

The Diesse Ves-matic system for measuring the ESR is designed to overcome several draw-

*Table 2 False low ESR values (mean and 95% confidence interval) compared with baseline after storage of blood for 24 hours at 4°C*

	False low ESR		
	Mean (mm/1h)	95% CI (mm/1h)	n
Junior Ves-tec	4.2	3.3 to 5.1	243
Senior Ves-tec	4.9	4.0 to 5.8	117
Junior Vacu-tec	5.4	4.3 to 6.6	201
Senior Vacu-tec	5.7	4.3 to 7.1	68

Figure 8 Comparability between the ICSH undiluted ESR and the Junior Vacu-tec ESR. Lines represent equality  $\pm 12$  mm/1h ( $n = 73$ ).

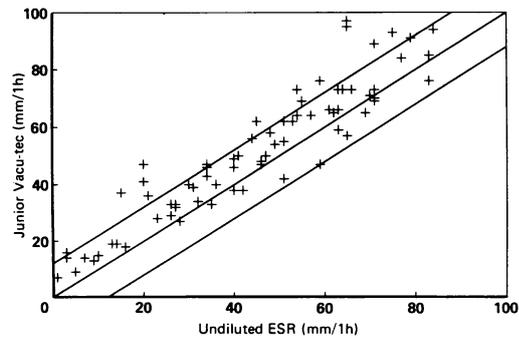
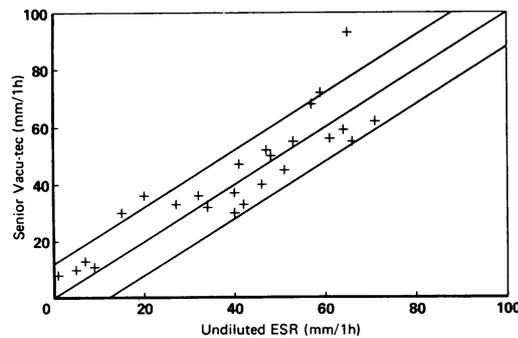


Figure 9 Comparability between the ICSH undiluted ESR and the Senior Vacu-tec ESR. Lines represent equality  $\pm 12$  mm/1h ( $n = 25$ ).



backs of Westergren ESR methodology. The main improvements are claimed to be standardisation of dilution of blood with anticoagulant-diluent, standardisation of the degree of mixing and therefore red cell aggregation at the start of the test, and adjustment for temperature. A small volume of blood (about 1 ml) is required for the test and the result is obtained within 25 minutes compared with the 60 minutes required for the Westergren ESR. Faster sedimentation is possible because of the Boycott phenomenon,<sup>14</sup> by which red cells sediment more quickly when streaming down the wall of an angled tube than when falling vertically. The usefulness of the Ves-matic system is also increased by the reduction in operator time required to set up the test and read the results; the latter can be sent directly to a laboratory computer. Thus the Ves-matic system incorporates several improvements over previous ESR methodology.

Satisfactory precision was obtained over a range of ESR values but, as expected, precision deteriorated at low rates of sedimentation. We then compared the Ves-matic system with both the 1977 ICSH Westergren<sup>6</sup> and 1988 ICSH undiluted<sup>7</sup> ESR methods. Manually filled Ves-matic samples showed good agreement with both ICSH methods but with a tendency to false low results at low ESR values; this may be a consequence of the higher dilution of blood with citrate in Ves-matic tubes (ratio 2.8:1) compared with the ratio of 4:1 of the ICSH Westergren ESR.<sup>15</sup> Vacuum filled Vacu-tec samples also showed good agreement with ICSH values but with a tendency to false high results. The reasons for this are unclear, although the storage life of the tubes may play a part. During storage of certain plastic tubes, there may be progressive loss of vacuum and the amount of citrate diluent may change due to loss of water vapour through the plastic or absorption of citrate to the plastic.<sup>16</sup> The ratio

of blood:citrate may therefore change during storage and affect the ESR result. Dilution of blood with citrate affects the ESR in two ways. The concentration of plasma proteins, such as fibrinogen and gamma globulin that cause red cells to aggregate, will be reduced by dilution leading to a slowing down of red cell sedimentation. The red cells are also diluted, however, which tends to accelerate sedimentation. Even though the decrease in volume of citrate may fortuitously balance the loss of vacuum to give an unchanged ratio, as in the present study after three to four and 10–11 months' storage, the effect on the ESR result cannot be assumed to be consistent throughout the 12 month storage life as the ratio does change during this time. Manufacturers should establish with care the storage life of their tubes.

A representative range of inflammatory disorders was studied in the 252 patients with no evidence that comparability between the 20 minute Ves-matic end point and the 60 minute Westergren end point differed between disorders. The Diesse Ves-matic system is attractive to the routine diagnostic laboratory and incorporates several improvements over previous ESR technology, making the ESR a safer, quicker, and more standardised test.

We are indebted to Diesse Diagnostica Senese Srl and Biomen Limited, Croydon, for provision of the Ves-matic instruments and blood collection tubes used in this study.

- Fåhræus R. The suspension-stability of the blood. *Acta Med Scand* 1921;55:1–228.
- Westergren A. Studies on the suspension stability of the blood in pulmonary tuberculosis. *Acta Med Scand* 1921;54:247–82.
- Haybittle JL, Hayhoe FGJ, Easterling MJ, *et al.* Review of British National Lymphoma Investigation studies of Hodgkin's disease and development of prognostic index. *Lancet* 1985;ii:967–72.
- Imai K, Suzuki T, Kobayashi M, Yamanaka H, Tomaru Y, Sato J. The significance of erythrocyte sedimentation rate as a prognostic factor for patients with prostate cancer: Gunma Urological Oncology Study Group. *Jpn J Cancer Res* 1990;81:971–4.
- Bull BS, Westergren JC, Farr M, Bacon PA, Meyer PJ, Stuart J. Efficacy of tests to monitor rheumatoid arthritis. *Lancet* 1989;ii:965–7.
- International Committee for Standardization in Haematology. Recommendation for measurement of erythrocyte sedimentation rate in human blood. *Am J Clin Pathol* 1977;68:505–7.
- International Committee for Standardization in Haematology (Expert Panel on Blood Rheology). Guidelines on selection of laboratory tests for monitoring the acute phase response. *J Clin Pathol* 1988;41:1203–12.
- Patton WN, Meyer PJ, Stuart J. Evaluation of sealed vacuum extraction method (Seditainer) for measurement of erythrocyte sedimentation rate. *J Clin Pathol* 1989;42:313–7.
- Jou JM, Insa MJ, Aymerich M, Vives Corrons JL. Evaluación de un sistema totalmente automático para realizar la velocidad de sedimentación globular. *Sangre* 1988;33:474–8.
- Prischl FC, Schwarzmeier JD. Automatisierte Bestimmung der Blutkörperchen-Senkungsgeschwindigkeit (Ves-Matic): Einsatz im Krankenhaus. *Berichte der ÖGKC* 1988;11:112–4.
- De Castro MF, Calle PF, Vilorio A, Larrocha C, Jiménez MC. Valoración de un sistema alternativo totalmente automatizado para la determinación de la velocidad de sedimentación globular. *Sangre* 1989;34:4–9.
- Koepke JA, Caracappa P, Johnson L. The evolution of erythrocyte sedimentation rate methodology. *Labmedica* 1990;7:46–8.
- Bland JM, Altman DG. Statistical method for assessing agreement between two methods of clinical measurement. *Lancet* 1986;i:307–10.
- Ponder E. On sedimentation and rouleaux formation-1. *Q J Exp Physiol* 1925;15:235–52.
- Moseley DL, Bull BS. A comparison of the Wintrobe, the Westergren and the ZSR erythrocyte sedimentation rate (ESR) methods to a candidate reference method. *Clin Lab Haematol* 1982;4:169–78.
- Arnaud V, Dauphin M, Mignot A. Interactions matières plastiques-médicaments. In: Postaire E, ed. *Les Matières Plastiques à Usage Pharmaceutique et Médico-Chirurgical*. Volume 1. Paris: Editions Médicales Internationales, 1986:121–38.

contain details of recently described lesions such as hepatoid ovarian carcinoma and the hepatoid variant of yolk sac tumour. Their contribution on the peritoneum gives good illustrated descriptions of benign lymph node inclusions of glandular, decidual, and smooth muscle tissue, endosalpingiosis and extra ovarian serous and mucinous lesions, which are not adequately covered in other text books. The chapter on the vulva and vagina includes the latest classification of vulvar dystrophies.

This book is insufficiently detailed across the range of subjects to be used as a diagnostic benchbook but it does give a convenient source of easy reference to recent developments. It represents good value for money and well suits the needs of doctors working for the MRCPATH. I recommend it for the postgraduate or personal library.

LJR BROWN

**A Guide to Infectious Diseases.** MG Brook, MF McGhee. (Pp 236; soft cover £12.50). Radcliffe Medical Press. 1991. ISBN 1-870905-60-1.

This paperback was written by a senior registrar in infectious and tropical diseases and a general medical practitioner. Its aim is to be a concise up to date aide-memoire suitable as a rapid reference on the more common and important infectious diseases for non-specialist hospital doctors, medical students, nurses and general practitioners. There are 17 chapters, beginning with one of four pages on epidemiology and public health aspects of infection, and continuing with chapters on infections of systems such as the central nervous system, heart, and so on. Chapter 10 on infections around the eye is well done and is followed by a concise chapter on the exanthemata, infection related rashes, and childhood infectious diseases. There is a good chapter on human immunodeficiency virus and its complications. The last four chapters describe infection in the traveller, fever of unknown origin, miscellaneous diseases, immunisation and preservation of health. The latter is a guide to the various vaccines and immunoglobulins available with their use and sources of supply.

There are three appendices comprising the current list of notifiable diseases, a list of infections with their incubation periods, and a table of vaccinations for foreign travel along the lines of the checklist in the *Health Advice for Travellers* from the Department of Health. The print is easy to read and the pages are laid out clearly with headings and subheadings for the short paragraphs, notes, and lists which make up the text. Overall, the book succeeds in its aims but I doubt whether readers of the Journal will wish to buy it.

RN PEEL

**Incidental Carcinoma of the Prostate.** Ed JE Altwein, P Faul, W Schneider. (Pp 310; DM 118). Springer-Verlag. 1991. ISBN 3-540-53225-0.

The general pathologist in search of an update, seeing the title of this book, will want reassurance that there is guidance on how to

make the diagnosis, the site and type of surgical specimens in which such lesions would be expected, and some insight into the general clinical relevance of the possible histological findings.

To what extent does the book fulfil a jaded, or a spritely trainee histopathologist's needs? In fact, happily, most of the questions set above are answered beyond expectation. The only problem is how to thresh the wheat from the chaff. Naturally, other clinical specialties concerned with uropathology would make quite separate piles of wheat and chaff. It is true that there is a little chaff, but the answers to morphological diagnosis are given in Helpap's chapter, the site and relevant specimens are in Battaglia's and Schroder's, the general clinical relevance in Schulze's and many others. If you are even just passingly curious about prostatic diagnostic histopathology, this book is worth reading.

The book itself is arranged as a series of 41 articles. The hard-back binding, typography, illustrations and tables are presented to the exceptional high standard which has long characterised the publications of Springer-Verlag. Purchase for any diagnostic histopathology department involved in the routine assessment of prostates is recommended. The cost will not take long to justify itself.

JD DAVIES

## Some new titles

The receipt of books is acknowledged, and this listing must be regarded as sufficient return for the courtesy of the sender. Books that appear to be of particular interest will be reviewed as space permits.

**Drug Safety. A Shared Responsibility.** (Pp 144; £9.95.) Churchill Livingstone 1991. ISBN 0 443 04655 7.

## NOTICES

### ACP Locum Bureau

The Association of Clinical Pathologists runs a locum bureau for consultant pathologists.

Applicants with the MRCPATH who would like to do locums and anyone requiring a locum should contact The General Secretary, School of Biological Sciences, Falmer, Brighton, BN1 9QC. Tel and Fax: 0273 678435.

### Fifth Workshop on Gastrointestinal Pathology and Helicobacter Pylori

Trinity College, Dublin, Ireland

6-7 July 1992

Conference Secretariat:

CRUINNIU, 3 St Kevins Park, Dartry, Dublin 6.

Telephone: 353-1-971710.

Fax: 353-1-965983.

### Fifth Meeting and Workshop of the European Association for Haematopathology

21-25 September 1992

Bologna, Italy

*The Meeting* (21-23 September) will include a two day session devoted to the monocyte/macrophage system with special reference to the physiology, pathology, immunophenotyping and molecular genetics. The topic of the third day will be recent advances in haematopathology.

Fee: 410 DM

(or 470 DM if paid after 29 February 1992).

*The Workshop* (24-25 September) will focus on the reactive and neoplastic proliferations of the monocyte/macrophage system.

Admission will depend on the submission of a case and on its selection by the panel of experts.

Fee: 170 DM

(to be paid before 31 May 1992).

The deadline for the submission of abstracts and cases is 29 February 1992. Further details are available from the EAHP local organiser: Professor Stefano Pileri, Emolinopatia, Istituto di Ematologia/II, Servizio di Anatomia Patologica, Via Massarenti 9, 40138 Bologna, Italy. Telephone: 39-51-6364674. Fax: 39-51-388973; or from the organising secretariat: ICARIA, Via Zannoni 45, 40134 Bologna, Italy. Telephone: 39-51-416690/410773. Fax: 39-51-421526.

### VIIth International Symposium on the Biology of Vascular Cells

November 10-14, 1992

San Diego, California

The purpose of this meeting is to develop an accurate and current understanding of the role of vascular cells in biology and disease. This goal will be accomplished both through formal presentations and through an active informal discussion/social programme. This conference will be held at the Princess Resort located on a 44 acre island in San Diego's Mission Bay.

For further information contact: Department of Academic Affairs, 403C Scripps Clinic and Research Foundation, 10666 N. Torrey Pines Road, La Jolla, CA 92037. Telephone: (619) 554-8556.

### Correction

An error appeared in the vertical axis to fig 2 of "Assessment of DIESSE Ves-matic automated system for measuring erythrocyte sedimentation rate" by M Caswell and J Stuart *J Clin Pathol* 1991;44:946-49. It should read, Junior Ves-tec and not Vaw-tec, as published.