

Piccolo[®] Liver Panel Plus



For In Vitro Diagnostic Use and For Professional Use Only **Applicable to US customers only**

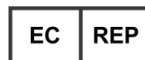
Customer and Technical Service: 1- 800-822-2947

Customers outside the US: +49 6155 780 210

CLIA Waived: Use lithium heparin whole blood, only
Moderate Complexity: Use lithium heparin whole blood, lithium heparin plasma, or serum



Abaxis, Inc.
3240 Whipple Rd.
Union City, CA 94587
USA



ABAXIS Europe GmbH
Bunsenstr. 9-11
64347 Griesheim
Germany

1. Intended Use

The Piccolo[®] Liver Panel Plus, used with the Piccolo[®] blood chemistry analyzer or the Piccolo Xpress[®] chemistry analyzer, utilizes dry and liquid reagents to provide in vitro quantitative determinations of alanine aminotransferase, albumin, alkaline phosphatase, amylase, aspartate aminotransferase, gamma glutamyltransferase, total bilirubin, and total protein in heparinized whole blood, heparinized plasma, or serum in a clinical laboratory setting or point-of-care location.

For US Customers Only

The tests on this panel are waived under CLIA '88 regulations. If a laboratory modifies the test system instructions, then the tests are considered high complexity and subject to all CLIA requirements. For CLIA waived labs, only lithium heparin whole blood may be tested. For use in moderate complexity labs, lithium heparinized whole blood, lithium heparinized plasma, or serum may be used.

A CLIA Certificate of Waiver is needed to perform CLIA waived testing. A Certificate of Waiver can be obtained from the Centers for Medicare & Medicaid Services (CMS). Please contact the Commission on Laboratory Accreditation (COLA) at 1-800-981-9883 for assistance in obtaining one.

2. Summary and Explanation of Tests

The Piccolo Liver Panel Plus and the Piccolo blood chemistry analyzer or the Piccolo Xpress chemistry analyzer comprise an *in vitro* diagnostic system that aids the physician in diagnosing the following disorders.

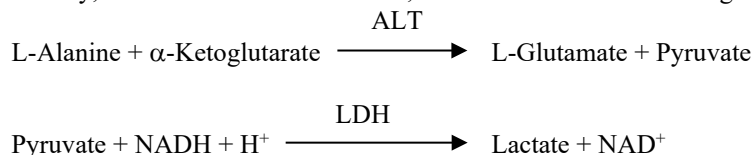
Alanine aminotransferase:	Liver diseases, including viral hepatitis and cirrhosis; heart diseases.
Albumin:	Liver and kidney diseases.
Alkaline phosphatase:	Liver, bone, parathyroid, and intestinal diseases.
Amylase:	Pancreatitis.
Aspartate aminotransferase:	Liver disease including hepatitis and viral jaundice, shock.
Gamma glutamyltransferase:	Liver diseases, including alcoholic cirrhosis and primary and secondary liver tumors.
Total bilirubin:	Liver disorders, including hepatitis and gall bladder obstruction; jaundice.
Total protein:	Liver, kidney, bone marrow diseases; metabolic and nutritional disorders.

3. Test Principles

Alanine Aminotransferase (ALT)

Alanine aminotransferase (ALT) has been measured by three methods. Two of these methods—the colorimetric dinitrophenylhydrazine coupling technique^{1,2} and the fluorescent enzymatic assay—are rarely used.³ An enzymatic method based on the work of Wróblewski and LaDue⁴ is the most common technique for determining ALT concentrations in serum. A modified Wróblewski and LaDue procedure has been proposed as the recommended procedure of the International Federation of Clinical Chemistry (IFCC).⁵

The method developed for use on the Piccolo blood chemistry analyzer or the Piccolo Xpress chemistry analyzer is the same as that recommended by the IFCC but run at a higher temperature. In this reaction, ALT catalyzes the transfer of an amino group from L-alanine to α -ketoglutarate to form L-glutamate and pyruvate. Lactate dehydrogenase catalyzes the conversion of pyruvate to lactate. Concomitantly, NADH is oxidized to NAD^+ , as illustrated in the following reaction scheme.

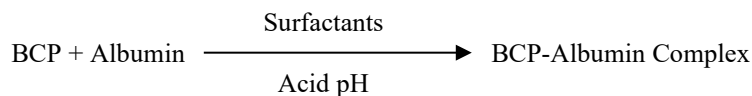


The rate of change of the absorbance difference between 340 nm and 405 nm is due to the conversion of NADH to NAD^+ and is directly proportional to the amount of ALT present in the sample.

Albumin (ALB)

Early methods used to measure albumin include fractionation techniques^{6,7,8} and tryptophan content of globulins.^{9,10} These methods are unwieldy to perform and do not have a high specificity. Two immunochemical techniques are considered as reference methods, but are expensive and time consuming.¹¹ Dye binding techniques are the most frequently used methods for measuring albumin. Bromocresol green (BCG) is the most commonly used of the dye binding methods but may over-estimate albumin concentration, especially at the low end of the normal range.¹² Bromocresol purple (BCP) is the most specific of the dyes in use.^{13,14}

Bromocresol purple, when bound with albumin, changes from a yellow to blue color. The absorbance maximum changes with the color shift.

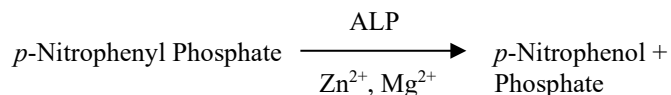


Bound albumin is proportional to the concentration of albumin in the sample. This is an endpoint reaction that is measured as the difference in absorbance between 600 nm and 550 nm.

Alkaline Phosphatase (ALP)

Techniques to measure alkaline phosphatase were first developed over 60 years ago. Several of these end-point or two-point spectrophotometric methods^{15,16} are now considered obsolete or too cumbersome. The use of *p*-nitrophenyl phosphate (*p*-NPP) increased the speed of the reaction.^{17,18} The reliability of this technique was greatly increased by the use of a metal-ion buffer to maintain the concentration of magnesium and zinc ions in the reaction.¹⁹ The American Association for Clinical Chemistry (AACC) reference method²⁰ uses *p*-NPP as a substrate and a metal-ion buffer.

The Piccolo procedure is modified from the AACC²⁰ and IFCC²¹ methods. Alkaline phosphatase hydrolyzes *p*-NPP in a metal-ion buffer and forms *p*-nitrophenol and phosphate.

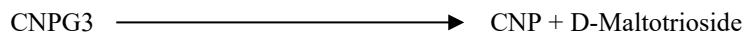


The amount of ALP in the sample is proportional to the rate of increase in absorbance difference between 405 nm and 500 nm.

Amylase (AMY)

About 200 different tests have been developed to measure amylase. Most procedures use a buffered polysaccharide solution but employ different detection techniques. Viscosimetric methods are lacking in precision and accuracy²², while turbidimetric and iodometric methods are difficult to standardize.^{23,24} Commonly used are saccharogenic and chromolytic methods. The “classic” amylase measurement technique is a saccharogenic method²⁵, but is difficult and time-consuming.²⁶ Chromolytic methods using *p*-nitrophenylglycosides as substrates have been recently developed.²⁷ These assays have a higher specificity for pancreatic amylase than for salivary amylase and are easily monitored.²⁷

In the Piccolo method, the substrate, 2-chloro-*p*-nitrophenyl- α -D-maltotrioxide (CNPG3), reacts with α -amylase in the patient sample, releasing 2-chloro-*p*-nitrophenol (CNP). The release of CNP creates a change in color.

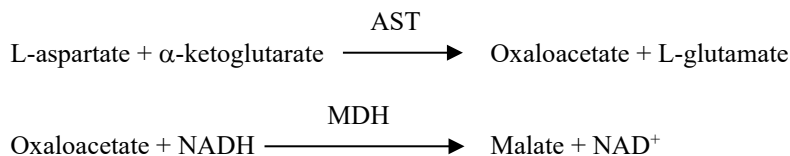


The reaction is measured bichromatically at 405 nm and 500 nm. The change in absorbance due to the formation of CNP is directly proportional to $\square\alpha$ -amylase activity in the sample.

Aspartate Aminotransferase (AST)

The aspartate aminotransferase (AST) test is based on the Karmen rate method²⁸ as modified by Bergmeyer.²⁹ The current International Federation of Clinical Chemistry (IFCC) reference method utilizes the Karmen/Bergmeyer technique of coupling malate dehydrogenase (MDH) and reduced nicotinamide dinucleotide (NADH) in the detection of AST in serum.^{29,30} Lactate dehydrogenase (LDH) is added to the reaction to decrease interference caused by endogenous pyruvate.

AST catalyzes the reaction of L-aspartate and α -ketoglutarate into oxaloacetate and L-glutamate. Oxaloacetate is converted to malate and NADH is oxidized to NAD^+ by the catalyst MDH.

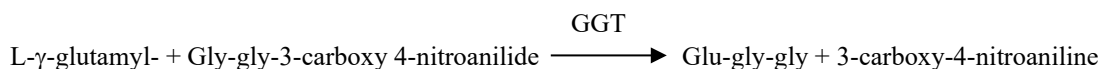


The rate of absorbance change at 340 nm/405 nm caused by the conversion of NADH to NAD^+ is directly proportional to the amount of AST present in the sample.

Gamma Glutamyltransferase (GGT)

The first quantitative methods developed to measure gamma glutamyltransferase (GGT) involved a second reaction to form an azo dye that combined with a chromophore.^{39,40} The change to L- γ -glutamyl-*p*-nitroanilide as the substrate in the reaction eliminated the dye-formation step.⁴¹ Due to the poor solubility and stability of L- γ -glutamyl-*p*-nitroanilide, this procedure was modified to use the substrate L- γ -glutamyl-3-carboxy-4-nitroanilide.⁴² The International Federation of Clinical Chemistry (IFCC) recommended GGT method is based on the latter substrate, with glycylglycine as the other substrate.⁴³

Abaxis has modified the IFCC method to react at 37°C. The addition of sample containing gamma glutamyltransferase to the substrates L- γ -glutamyl-3-carboxy-4-nitroanilide and glycylglycine (gly-gly) causes the formation of L- γ -glutamyl-glycylglycine (glu-gly-gly) and 3-carboxy-4-nitroaniline.

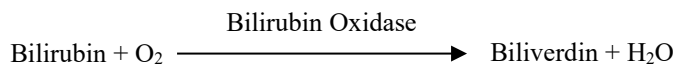


The absorbance of this rate reaction is measured at 405 nm. The production of 3-carboxy-4-nitroaniline is directly proportional to the GGT activity in the sample.

Total Bilirubin (TBIL)

Total bilirubin levels have been typically measured by tests that employ diazotized sulfanilic acid.^{32,44} A newer, more specific method has been developed using the enzyme bilirubin oxidase.^{34,35,36} In addition to using the more specific total bilirubin test method, photodegradation of the analyte is minimized in the Piccolo System because the sample can be tested immediately after collection.

In the enzyme procedure, bilirubin is oxidized by bilirubin oxidase into biliverdin. The final reaction is the conversion of biliverdin into various purple compounds.

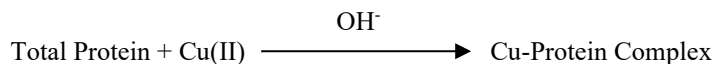


Bilirubin is quantitated as the difference in absorbance between 467 nm and 550 nm. The initial absorbance of this endpoint reaction is determined from the bilirubin blank cuvette and the final absorbance is obtained from the bilirubin test cuvette. The amount of bilirubin in the sample is proportional to the difference between the initial and final absorbance measurements.

Total Protein (TP)

The total protein method is a modification of the biuret reaction, noted for its precision, accuracy, and specificity.⁴⁵ Originally developed by Riegler⁴⁶ and modified by Weichselbaum⁴⁷, Dumas, et al⁴⁸ proposed a biuret reaction as a candidate total protein reference method.

In the biuret reaction, the protein solution is treated with cupric [Cu(II)] ions in a strong alkaline medium. Sodium potassium tartrate and potassium iodide are added to prevent the precipitation of copper hydroxide and the autoreduction of copper, respectively.⁴⁷ The Cu(II) ions react with peptide bonds between the carbonyl oxygen and amide nitrogen atoms to form a colored Cu-Protein complex.



The amount of total protein present in the sample is directly proportional to the absorbance of the Cu-protein complex. The total protein test is an endpoint reaction and the absorbance is measured as the difference in absorbance between 550 nm and 850 nm.

4. Principles of Procedure

See the Piccolo blood chemistry analyzer or the Piccolo Xpress chemistry analyzer Operator's Manual, for the principles of procedure.

5. Description of Reagents

Reagents

Each Piccolo Liver Panel Plus reagent disc contains dry test-specific reagent beads (described below). A dry sample blank reagent (comprised of buffer, surfactants, excipients, and preservatives) is included in each disc for use in calculating concentrations of alanine aminotransferase (ALT), albumin (ALB), alkaline phosphatase (ALP), amylase (AMY), aspartate aminotransferase (AST), and gamma glutamyltransferase (GGT). Dedicated sample blanks are included in the disc for total bilirubin, and total protein. Each reagent disc also contains a liquid diluent consisting of surfactants, excipients, and preservatives.

Table 1: Reagents

Component	Quantity/Disc
Alanine Aminotransferase Reagent	
L-alanine	874 µg
α-ketoglutaric acid	54 µg
β-nicotinamide adenine dinucleotide reduced (NADH)	7 µg
Lactate dehydrogenase (LDH) (<i>Staphylococcus epidermidis</i>)	0.09 U
Buffers, surfactant, excipients, and preservatives	
Albumin Reagent	
Bromocresol purple, sodium salt	2 µg
Buffer, surfactant, excipients, and preservatives	
Alkaline Phosphatase Reagent	
Magnesium chloride	3 µg
Zinc sulfate	3 µg
p-NPP, disodium salt	56 µg
Buffers, surfactant, excipients, and preservatives	
Amylase Reagent	
CNPG3	40 µg
Buffer, surfactant, excipients, and preservatives	

Table 1 continued: Reagents

Component	Quantity/Disc
Aspartate Aminotransferase Reagent	
L-aspartic acid	426 µg
Lactate dehydrogenase (LDH) (<i>Staphylococcus epidermidis</i>)	0.04 U
β-nicotinamide adenine dinucleotide, reduced (NADH)	5 µg
Malate dehydrogenase (MDH) (porcine heart)	0.01 U
α-ketoglutaric acid	28 µg
Buffers, surfactant, excipients, and preservatives	
Gamma Glutamyltransferase Reagent	
Glycylglycine	317 µg
L-glutamic acid γ-(3-carboxy-4-nitroanilide)	30 µg
Buffer, surfactant, excipients, and preservatives	
Total Bilirubin Reagent	
Beckman Bilirubin Enzyme Reagent	0.1 U
Buffer, excipients, and preservatives	
Total Bilirubin Blank	
Buffer, excipients, and preservatives	
Total Protein Reagent	
Sodium potassium tartrate	343 µg
Cupric sulfate	134 µg
Potassium iodide	28 µg
Excipients and preservatives	
Total Protein Blank	
Sodium potassium tartrate	343 µg
Potassium iodide	28 µg
Excipients and preservatives	

Warnings and Precautions

- The diluent container in the reagent disc is automatically opened when the analyzer drawer closes. A disc with an opened diluent container can not be re-used. Ensure that the sample or control has been placed into the disc before closing the drawer.
- Used reagent discs contain human body fluids. Follow good infection control practices when handling and disposing used discs.⁴⁹ See the Piccolo blood chemistry analyzer or the Piccolo Xpress chemistry analyzer Operator’s Manual for instructions on cleaning biohazardous spills.
- The reagent discs are plastic and may crack or chip if dropped. **Never** use a dropped disc as it may spray bio-hazards throughout the interior of the analyzer.
- Reagent beads may contain acids or caustic substances. The operator does not come into contact with the reagent beads when following the recommended procedures. In the event that the beads are handled (e.g., cleaning up after dropping and cracking a reagent disc), avoid ingestion, skin contact, or inhalation of the reagent beads.
- Reagent beads and diluent contain sodium azide which may react with lead and copper plumbing to form highly explosive metal azides. Reagents will not come into contact with lead and copper plumbing when following recommended procedures. However, if the reagents do come into contact with such plumbing, flush with a large volume of water to prevent azide buildup.

Storage

Store reagent discs in their sealed pouches at 2-8°C (36-46°F). To use reagent discs, remove the discs in their sealed foil pouches from the refrigerator. Discs in sealed pouches can be left at room temperature and then placed back in the refrigerator several times. Ensure that the total time discs are at room temperature does not exceed 48 hours. Open the pouch and remove the disc just prior to running the test.

Do not expose discs, in or out of the foil pouches, to direct sunlight or to temperatures above 32°C (90°F). A disc must be used within 20 minutes of opening the pouch; a disc in an opened pouch can not be placed back in the refrigerator for use at a later time.

Indications of Reagent Disc Instability/Deterioration

Do **not** use a disc:

- after the expiration date. An error message will appear on the Piccolo blood chemistry analyzer or the Piccolo Xpress chemistry analyzer display if you use an expired disc;
- from a torn or otherwise damaged pouch; or
- if the desiccant is pink as observed through the strip of the packet enclosed in the disc pouch.

6. Instrument

See the Piccolo blood chemistry analyzer or the Piccolo Xpress chemistry analyzer Operator's Manual for complete information on using the analyzer.

7. Sample Collection and Preparation

Sample collection techniques are described in the Piccolo blood chemistry analyzer or the Piccolo Xpress chemistry analyzer Operator's Manual.

- The minimum required sample size is ~90 µL of heparinized whole blood, heparinized plasma, serum, or serum control. The reagent disc sample chamber can contain up to 120 µL of sample.
- Whole blood samples obtained by venipuncture must be homogeneous before transferring a sample to the reagent disc. Gently invert the collection tube several times just prior to sample transfer. Do **not** shake the collection tube; shaking can cause hemolysis.
- Whole blood venipuncture samples should be run within 60 minutes of collection.⁵⁰ Refrigerating whole blood samples can cause significant changes in concentrations of **aspartate aminotransferase**.⁵¹ The sample may be separated into plasma or serum and stored in capped sample tubes at 2-8°C (36-46°F) if the sample can not be run within 60 minutes.
- **Total Bilirubin** results may be adversely affected by photodegradation. Whole blood samples not run immediately should be stored in the dark for no longer than 60 minutes. If the sample can not be analyzed within that period, it should be separated into plasma or serum and stored in a capped sample tube in the dark at low temperatures.⁵²

Known Interfering Substances

- The only anticoagulant recommended for use in the Piccolo test protocol is lithium heparin. Abaxis has performed studies demonstrating that EDTA, fluoride, oxalate, and any anticoagulant containing ammonium ions will interfere with at least one chemistry contained in the Piccolo Liver Panel Plus.
- **Amylase** is secreted by several glands as well as by the pancreas. Only pancreatic amylase is of clinical interest.⁵³ Contamination of a sample with nonpancreatic amylase will cause artificially elevated results. Finger puncture samples are more prone to contamination than are venipuncture samples. If amylase results from a finger puncture sample are not consistent with the patient's clinical symptoms, repeat the test using a venipuncture sample.
- Interference may be seen in the **total protein** test when analyzing samples with a triglyceride concentration >400 mg/dL may show an increased total protein level. The Piccolo analyzer or the Piccolo Xpress chemistry analyzer suppresses any results that are affected by >10% interference from lipemia. "LIP" is printed on the result card in place of the result.

8. Procedure

Materials Required

Refer to the Piccolo blood chemistry analyzer or the Piccolo Xpress chemistry analyzer Operator's Manual, for information on ordering the materials needed to operate the Piccolo blood chemistry analyzer or the Piccolo Xpress chemistry analyzer according to the recommended procedure.

- One Piccolo Liver Panel Plus PN: 400-1003 (a box of discs PN: 400-0003)

Materials Required but not Provided

- Piccolo blood chemistry analyzer or the Piccolo Xpress chemistry analyzer
- Sample transfer pipettes (fixed volume approximately 100 μ L) and tips are provided with each Piccolo blood chemistry analyzer or the Piccolo Xpress chemistry analyzer and may be reordered from Abaxis.
- Commercially available control reagents recommended by Abaxis (contact Abaxis Technical Service for approved control materials and expected values).
- Timer

Test Parameters

The Piccolo blood chemistry analyzer or the Piccolo Xpress chemistry analyzer operates at ambient temperatures between 15°C and 32°C (59-90°F). The analysis time for each Piccolo Liver Panel Plus is <14 minutes. The analyzer maintains the reagent disc at a temperature of 37°C (98.6°F) over the measurement interval.

Test Procedure

The complete sample collection and step-by-step operating procedures are detailed in the Piccolo blood chemistry analyzer or the Piccolo Xpress chemistry analyzer Operator's Manual.

Quality Control

See Section 2.4 of the Piccolo blood chemistry analyzer Operator's Manual or Section 6 (Calibration and Quality Control) of the Piccolo Xpress chemistry analyzer Operator's Manual. Performance of the Piccolo blood chemistry analyzer or the Piccolo Xpress chemistry analyzer can be verified by running controls. For a list of approved quality control materials with acceptance ranges, please contact Abaxis Technical Support. Other human serum or plasma-based controls may not be compatible. Quality control materials should be stored as per the package-insert included with the controls.

If control results are out of range, repeat one time. If still out of range, call Technical Support. Do not report results if controls are outside their labeled limits. See the Piccolo blood chemistry analyzer or Piccolo Xpress chemistry analyzer Operator's Manual for a detailed discussion on running, recording, interpreting, and plotting control results.

Waived Laboratories: Abaxis recommends control testing as follows:

- at least every 30 days
- whenever the laboratory conditions have changed significantly, e.g. Piccolo moved to a new location or changes in temperature control
- when training or retraining of personnel is indicated
- with each new lot (CLIA waived tests in waived status labs)

Non-Waived Laboratories: Abaxis recommends control testing to follow federal, state, and local guidelines.

Calibration

The Piccolo blood chemistry analyzer or the Piccolo Xpress chemistry analyzer is calibrated by the manufacturer before shipment. The bar code printed on the bar code ring provides the analyzer with reagent disc-specific calibration data. See the Piccolo blood chemistry analyzer or the Piccolo Xpress chemistry analyzer Operator's Manual.

9. Results

The Piccolo blood chemistry analyzer or the Piccolo Xpress chemistry analyzer automatically calculates and prints the analyte concentrations in the sample. Details of the endpoint and rate reaction calculations are found in the Piccolo chemistry blood analyzer or the Piccolo Xpress chemistry analyzer Operator's Manual. Interpretation of results is detailed in the Operator's Manual. Results are printed onto results cards or paper rolls supplied by Abaxis. The result or paper rolls have an adhesive backing for easy placement in the patient's files.

The reaction for each analyte occurs at 37°C (98.6°F).

10. Limitations of Procedure

General procedural limitations are discussed in the Piccolo blood chemistry analyzer or the Piccolo Xpress chemistry analyzer Operator's Manual.

- The only anticoagulant **recommended for use** with the Piccolo blood chemistry analyzer or Piccolo Xpress chemistry analyzer is **lithium heparin**. Do not use sodium heparin.
- It is recommended that **albumin** tests be run using venous whole blood or serum rather than finger puncture whole blood. Finger puncture sampling techniques may cause more cellular trauma than venipuncture techniques.
- Samples with hematocrits in excess of 62-65% packed red cell volume (a volume fraction of 0.62-0.65) may give inaccurate results. Samples with high hematocrits may be reported as hemolyzed. These samples may be spun down to get plasma and then re-run in a new reagent disc.
- **Amylase** is secreted by several glands as well as by the pancreas. Only pancreatic amylase is of clinical interest.⁵³ Contamination of a sample with nonpancreatic amylase will cause artificially elevated results. Finger puncture samples are more prone to contamination than are venipuncture samples. If amylase results from a finger puncture sample are not consistent with the patient's clinical symptoms, repeat the test using a venipuncture sample.
- **Any result for a particular test that exceeds the assay range should be analyzed by another approved test method or sent to a referral laboratory. Do not dilute the sample and run it again on the Piccolo blood chemistry analyzer or the Piccolo Xpress chemistry analyzer.**

Warning: Extensive testing of the Piccolo blood chemistry analyzer or the Piccolo Xpress chemistry analyzer has shown that, in very rare instances, sample dispensed into the reagent disc may not flow smoothly into the sample chamber. Due to the uneven flow, an inadequate quantity of sample may be analyzed and several results may fall outside the expected ranges. The sample may be re-run using a new reagent disc.

Interference

Substances were tested as interferents with the analytes. Human serum pools were prepared. The concentration at which each potential interferent was tested was based on the testing levels in NCCLS EP7-A.¹⁵

Effects of Endogenous Substances

- Physiological interferents (hemolysis, icterus and lipemia) cause changes in the reported concentrations of some analytes. The sample indices are printed on the bottom of each printout to inform the operator about the levels of interferents present in each sample.
- The Piccolo blood chemistry analyzer or the Piccolo Xpress chemistry analyzer suppresses any results that are affected by >10% interference from hemolysis, lipemia or icterus. "HEM", "LIP", or "ICT" respectively, is printed on the printout in place of the result.
- For maximum levels of endogenous substances contact Abaxis Technical Service.
- Additionally, lactate at 230 mg/dL and lactate dehydrogenase at 10,000 U/L were found to have no effect on any of the assays on this disc.

Effects of Therapeutic Substances

The following compounds do not significantly interfere with the chemistries in the Piccolo reagent disc. Significant interference is defined as >10% shift in the result for a normal range specimen. Human serum pools were supplemented with known concentrations of the drugs or chemicals and then analyzed.

Therapeutic or Exogenous Substances	Concentration with No Significant Interference (mg/dL)	Physiologic or Therapeutic Range ⁵⁴⁻⁵⁷ (mg/dL)
Acetaminophen	100	1-2
Acetylsalicylic acid	50	2-10
Chloramphenicol	100	1-2.5
Cimetidine	16	0.1-1
Dextran	300	600-1800
Erythromycin	10	0.2-2.0
Hydrochlorothiazide	7.5	—
Isoniazide	4	0.1-0.7
Ketoprofen	50	—
Lidocaine	1	0.15-0.6
Methicillin	100	—
Methotrexate	0.5	0.1
Metronidazole	5	0.1
Nafcillin	1	—
Oxacillin	1	—
Phenytoin	3	1-2
Rifampin	0.5	0.4-3
Salicylic acid	25	15-30

The following substances showed greater than 10% interference. Significant interference is defined as >10% shift in the result for a normal range specimen. Human serum pools were supplemented with known concentrations of the drugs or chemicals and then analyzed.

	Concentration with Significant Interference (mg/dL)	Physiologic or Therapeutic Range ⁵⁴⁻⁵⁷ (mg/dL)	Interference
Alanine Aminotransferase (ALT)			
Ascorbic acid	20	0.8-1.2	11% inc*
Oxaloacetate	132	—	843% inc
Albumin (ALB)			
Acetoacetate	102	0.05-3.60	18% dec*
Ampicillin	30	0.5	12% dec
Caffeine	10	0.3-1.5	14% dec
Calcium chloride	20	—	17% dec
Cephalothin (Keflin)	400	10	13% inc
Ibuprofen	50	0.5-4.2	28% inc
α-Ketoglutarate	5	—	11% dec
Nitrofurantoin	20	0.2	13% dec
Proline	4	—	12% inc
Sulfalazine	10	2-4	14% dec
Sulfanilamide	50	10-15	12% dec
Theophylline	20	1-2	11% dec
Alkaline Phosphatase (ALP)			
Theophylline	20	1-2	42% dec
Total Bilirubin⁹ (TBIL)			
Dopamine	19	—	55% dec
L-dopa	5	—	17% dec

*inc=increase; dec=decrease

For additional information on potential chemical interferents, see the Bibliography.

11. Expected Values

Samples from a total of 193 adult males and females, analyzed on the Piccolo blood chemistry analyzer, were used to determine the reference ranges for alanine aminotransferase, albumin, alkaline phosphatase, amylase, total bilirubin, and total protein. Samples from a total of 186 adult males and females, analyzed on the Piccolo blood chemistry analyzer, were used to determine the reference ranges for aspartate aminotransferase. Samples from a total of 131 adult males and females, analyzed on the Piccolo blood chemistry analyzer, were used to determine the reference ranges for gamma glutamyltransferase.

These ranges are provided as a guideline only. It is recommended that your office or institution establish normal ranges for the geographic area in which you are located.

Table 2: Piccolo References Ranges

Analyte	Reference Range	
	Common Units	SI Units
Alanine Aminotransferase (ALT)	10-47 U/L	10-47 U/L
Albumin (ALB)	3.3-5.5 g/dL	33-55 g/L
Alkaline Phosphatase (ALP), Male	53-128 U/L	53-128 U/L
Alkaline Phosphatase (ALP), Female	42-141 U/L	42-141 U/L
Amylase (AMY)	14-97 U/L	14-97 U/L
Aspartate Aminotransferase (AST)	11-38 U/L	11-38 U/L
Gamma Glutamyltransferase (GGT)	5-65 U/L	5-65 U/L
Total Bilirubin (TBIL)	0.2-1.6 mg/dL	3.4-27.4 µmol/L
Total Protein (TP)	6.4-8.1 g/dL	64-81 g/L

Amylase is secreted by several glands as well as by the pancreas. Only pancreatic amylase is of clinical interest.⁵³ Contamination of a sample with nonpancreatic amylase will cause artificially elevated results. Finger puncture samples are more prone to contamination than are venipuncture samples. If amylase results from a finger puncture sample are not consistent with the patient's clinical symptoms, repeat the test using a venipuncture sample.

12. Performance Characteristics

Linearity

The chemistry for each analyte is linear over the dynamic range listed below when the Piccolo blood chemistry analyzer or the Piccolo Xpress chemistry analyzer is operated according to the recommended procedure (see the Piccolo blood chemistry analyzer or the Piccolo Xpress chemistry analyzer Operator's Manual).

Table 3: Piccolo Dynamic Ranges

Analyte	Dynamic Range	
	Common Units	SI Units
Alanine Aminotransferase (ALT)	5-2000 U/L	5-2000 U/L
Albumin (ALB)	1-6.5 g/dL	10-65 g/L
Alkaline Phosphatase (ALP)	5-2400 U/L	5-2400 U/L
Amylase (AMY)	5-4000 U/L	5-4000 U/L
Aspartate Aminotransferase (AST)	5-2000 U/L	5-2000 U/L
Gamma Glutamyltransferase (GGT)	5-3000 U/L	5-3000 U/L
Total Bilirubin(TBIL)	0.1-30 mg/dL	1.7-513 µmol/L
Total Protein (TP)	2-14 g/dL	20-140 g/L

If the analyte concentration is above the measuring range (dynamic range), but less than the system range, the printout will indicate a ">" sign at the upper limit and an asterisk after the number, e.g. ALT >2000* U/L. If lower than the dynamic range, a "<" will be printed with an asterisk, e.g. ALT <5* U/L. For values that are grossly beyond the measurement range (system range), "~~~" will be printed instead of a result. Any time "~~~" appears on a printout, collect a new sample and rerun the test. If results for the second sample are suppressed again, please call Abaxis Customer Service.

Sensitivity (Limits of Detection)

The lower limit of detection for each analyte is: alanine aminotransferase 10 U/L; albumin 1 g/dL (10 g/L); alkaline phosphatase 5 U/L; amylase 5 U/L; aspartate aminotransferase 5 U/L; gamma glutamyltransferase 5 U/L; total bilirubin 0.1 mg/dL (1.7 µmol/L); and total protein 2 g/dL (20 g/L).

Precision

Precision studies were conducted using NCCLS EP5-T2 guidelines.⁶⁰ Results for within-run and total precision were determined by testing two levels of control material.

Table 4: Precision (N=80)

Analyte	Within-Run	Total
Alanine Aminotranferase (U/L)		
<u>Control Level 1</u>		
Mean	21	21
SD	2.76	2.79
%CV	13.4	13.5
<u>Control Level 2</u>		
Mean	52	52
SD	2.70	3.25
%CV	5.2	6.2
Albumin (g/dL)		
<u>Control Level 1</u>		
Mean	5.6	5.6
SD	0.09	0.11
%CV	1.7	2.1
<u>Control Level 2</u>		
Mean	3.7	3.7
SD	0.07	0.11
%CV	2.0	2.9
Alkaline Phosphatase (U/L)		
<u>Control Level 1</u>		
Mean	39	39
SD	1.81	2.29
%CV	4.6	5.8
<u>Control Level 2</u>		
Mean	281	281
SD	4.08	8.75
%CV	1.5	3.1
Amylase (U/L)		
<u>Control Level 1</u>		
Mean	46	46
SD	2.40	2.63
%CV	5.2	5.7
<u>Control Level 2</u>		
Mean	300	300
SD	11.15	11.50
%CV	3.7	3.8

Table 4 continued: Precision (N=80)

Analyte	Within-Run	Total
Aspartate Aminotransferase (U/L)		
<u>Control Level 1</u>		
Mean	47	49
SD	0.98	0.92
%CV	2.07	1.88
<u>Control Level 2</u>		
Mean	145	147
SD	1.83	1.70
%CV	1.26	1.16
Gamma Glutamyltransferase (U/L)		
<u>Control Level 1</u>		
Mean	25	25
SD	0.59	0.74
%CV	2.34	2.94
<u>Control Level 2</u>		
Mean	106	106
SD	1.52	2.29
%CV	1.43	2.15
Total Bilirubin (mg/dL)		
<u>Control Level 1</u>		
Mean	0.8	0.8
SD	0.06	0.07
%CV	8.0	9.3
<u>Control Level 2</u>		
Mean	5.2	5.2
SD	0.09	0.15
%CV	1.7	2.8
Total Protein (g/dL)		
<u>Control Level 1</u>		
Mean	6.8	6.8
SD	0.05	0.08
%CV	0.8	1.2
<u>Control Level 2</u>		
Mean	4.7	4.7
SD	0.09	0.09
%CV	2.0	2.0

Correlation

Heparinized whole blood and serum samples were collected from patients at two sites. The whole blood samples were analyzed by the Piccolo blood chemistry analyzer at the field sites and the serum samples were analyzed by the Piccolo analyzer and by comparative methods. In some cases, high and low supplemented samples were used to cover the dynamic range. All samples were run in singlicate on the same day. Representative correlation statistics are shown in Table 5.

Table 5: Correlation of Piccolo blood chemistry analyzer with Comparative Method

	Whole Blood	
	Lab 1	Lab 2
Alanine Aminotransferase (U/L)		
Correlation	0.98	0.99
Slope	0.91	0.94
Intercept	1.3	-2.5
SEE	3.21	2.84
N	86	67
Sample range	10-174	10-174
Comparative method	Paramax®	Technicon
Albumin (g/dL)		
Correlation	0.85	0.90
Slope	1.0	0.88
Intercept	-0.3	-0.1
SEE	0.22	0.21
N	261	100
Sample range	1.1-5.3	1.5-5.0
Comparative method	Paramax®	Beckman
Alkaline Phosphatase (U/L)		
Correlation	0.99	0.93
Slope	0.97	1.14
Intercept	-5.9	-17.6
SEE	3.97	4.79
N	99	80
Sample range	27-368	26-150
Comparative method	Paramax®	Technicon
Amylase (U/L)		
Correlation	0.98	0.96
Slope	0.69	1.07
Intercept	-4.7	-4.1
SEE	3.11	3.47
N	99	80
Sample range	11-92	19-118
Comparative method	Paramax®	Technicon
Aspartate Aminotransferase (U/L)		
Correlation	0.93	1.0
Correlation	0.87	0.97
Slope	5.3	3.0
Intercept	2.76	1.90
SEE	159	46
N	13-111	13-252
Sample range	Paramax®	DAX™
Comparative method		
Gamma Glutamyltransferase (U/L)		
Correlation	1.0	1.0*
Slope	0.98	1.60*
Intercept	-0.4	3.1*
SEE	3.29	18.57*
N	135	49
Sample range	5-312	27-1848
Comparative method	Paramax®	Beckman

Table 5 continued: Correlation of Piccolo blood chemistry analyzer with Comparative Method

	Whole Blood	
	Lab 1	Lab 2
Total Bilirubin (mg/dL)		
Correlation	0.97	0.98
Slope	0.90	1.11
Intercept	0.0	-0.4
SEE	0.07	0.09
N	250	91
Sample range	0.2-3.7	0.1-6.4
Comparative method	Paramax®	Beckman
Total Protein (g/dL)		
Correlation	0.85	0.87
Slope	0.93	0.94
Intercept	0.6	0.3
SEE	0.19	0.16
N	251	92
Sample range	5.7-9.2	6.5-9.2
Comparative method	Paramax®	Beckman

*Laboratory 2 ran only serum on the Piccolo analyzer for the gamma glutamyltransferase test correlation.

Results of Untrained User Study

An “untrained user” study was conducted in which participants were given only the test instructions and asked to perform testing of 3 discs with blinded randomized samples. The samples consisted of serum pools prepared at three levels for each of the eight analytes, ALT, albumin, ALP, AMY, AST, GGT, total bilirubin, and total protein. The participants were not given any training on the use of the test. A total of approximately 60 participants were enrolled from 3 sites, representing a diverse demographic (educational, age, gender, etc) population.

Tables below present the summary of the performance for each analyte.

Alanine Aminotransferase (ALT)

	Level 1	Level 2	Level 3
N	62	62	62
Mean	45.4 U/L	98.9 U/L	184.3 U/L
%CV	3.7%	1.7%	1.5%
Observed Range	42 – 53	96 – 103	175 – 191
Percent of Results in the Range ± 15.0%*	98.4% 61/62 95%CI: 91.3% to 100%	100% 62/62 95%CI: 94.2% to 100%	100% 62/62 95%CI: 94.2% to 100%

* This percent is based on the premise that one cannot distinguish properly between normal and abnormal values when errors are greater than one-quarter of the normal range. The range of (10 U/L - 47 U/L) was considered.

Albumin (ALB)

	Level 1	Level 2	Level 3
N	62	62	62
Mean	3.0 g/dL	3.5 g/dL	4.2 g/dL
%CV	2.7%	2.5%	1.8%
Observed Range	2.9 – 3.2	3.3 – 3.7	4.0 – 4.4
Percent of Results in the Range ± 12.5%	100% 62/62 95%CI: 94.2% to 100%	100% 62/62 95%CI: 94.2% to 100%	100% 62/62 95%CI: 94.2% to 100%

Alkaline Phosphatase (ALP)

	Level 1	Level 2	Level 3
N	62	62	62
Mean	94.5 U/L	171.5 U/L	337.5 U/L
%CV	5.2%	3.2%	2.4%
Observed Range	85 – 106	160-184	287 – 388
Percent of Results in the Range ± 15.0%	100% 62/62 95%CI: 94.2% to 100%	100% 62/62 95%CI: 94.2% to 100%	100% 62/62 95%CI: 94.2% to 100%

Amylase (AMY)

	Level 1	Level 2	Level 3
N	62	62	62
Mean	72.1 U/L	126.9 U/L	260.0 U/L
%CV	2.4%	2.1%	1.9%
Observed Range	67 – 75	120 – 133	248 – 273
Percent of Results in the Range ± 15.0%	100% 62/62 95%CI: 94.2% to 100%	100% 62/62 95%CI: 94.2% to 100%	100% 62/62 95%CI: 94.2% to 100%

Aspartate Aminotransferase (AST)

	Level 1	Level 2	Level 3
N	62	62	62
Mean	56.0	120.4	276.3
%CV	2.4%	1.1%	1.0%
Observed Range	54 – 60	117 – 124	266 – 285
Percent of Results in the Range ± 15.0%	100% 62/62 95%CI: 94.2% to 100%	100% 62/62 95%CI: 94.2% to 100%	100% 62/62 95%CI: 94.2% to 100%

Gamma Glutamyltransferase (GGT)

	Level 1	Level 2	Level 3
N	62	62	62
Mean	35.0 U/L	86.2 U/L	131.3 U/L
%CV	2.8%	1.5%	1.5%
Observed Range	33 – 38	83 – 90	123 – 135
Percent of Results in the Range ± 15.0%	100% 62/62 95%CI: 94.2% to 100%	100% 62/62 95%CI: 94.2% to 100%	100% 62/62 95%CI: 94.2% to 100%

Total Bilirubin (TBIL)

	Level 1	Level 2	Level 3
N	62	62	62
Mean	0.86 mg/dL	2.5 mg/dL	5.7 mg/dL
%CV	6.1%	2.6%	1.8%
Observed Range	0.8 – 1.0	2.3 – 2.6	5.4 – 5.9
Percent of Results in the Range ± 15.0%	100% 62/62 95%CI: 94.2% to 100%	100% 62/62 95%CI: 94.2% to 100%	100% 62/62 95%CI: 94.2% to 100%

Total Protein (TP)

	Level 1	Level 2	Level 3
N	62	62	62
Mean	4.8 g/dL	5.7 g/dL	7.1 g/dL
%CV	2.0%	1.5%	1.5%
Observed Range	4.6 – 5.3	5.3 – 5.9	6.7 – 7.5
Percent of Results in the Range ± 5.9%	98.4% 61/62 95%CI: 91.3% to 100%	100% 62/62 95%CI: 94.2% to 100%	100% 62/62 95%CI: 94.2% to 100%

13. Symbols



Use By



Catalog Number



Batch Code



In Vitro Diagnostic
Medical Device



Consult Instructions
For Use



Manufacturer



Do Not Reuse



X Number of Test
Devices in Kit



Manufacturing
Sequence



Serial Number



Caution



Temperature
Limitation

PN:
Part Number



Authorized
Representative
In the European
Community



Denotes conformity to specified
European directives



UDI Barcode structure
in Health Industry Bar
Code (HIBC) standard
format



Unique Device Identifier
(UDI) in human and
machine-readable form
used to adequately identify
medical devices through
their distribution and use



Separate waste collection for
this electronic item indicated;
Equipment manufactured /
placed on the market after 13
August 2005; Indicates
compliance with Article 14(4) of
Directive 2012/19/EU (WEEE)
for the European Union (EU).

14. Bibliography

1. Tonhazy, NE, NG White, and WW Umbreit. 1950. A rapid method for the estimation of the glutamic-aspartic transaminase in tissues and its application to radiation sickness. *Arch Biochem* 28: 36-42.
2. Reitman, S and S Frankel. 1957. A colorimetric method for the determination of serum glutamic oxalacetic and glutamic pyruvic transaminases. *Am J Clin Pathol* 28: 56-63.
3. Murray, RL. 1989. Alanine aminotransferase. *In: LA Kaplan and AJ Pesce, eds., Clinical chemistry: theory, analysis, and correlation.* St. Louis: The C.V. Mosby Company; pp. 895-898.
4. Wróblewski, F and JS LaDue. 1956. Serum glutamic-pyruvic transaminase in cardiac and hepatic disease. *Proc Soc Exp Biol Med* 91: 569-571.
5. Bergmeyer, HU and M Hørder. 1980. IFCC methods for the measurement of catalytic concentration of enzymes. Part 3. IFCC method for alanine aminotransferase. *J Clin Chem Clin Biochem* 18: 521-534.
6. Howe, PE. 1921. The use of sodium sulfate as the globulin precipitant in the determination of proteins in blood. *J Biol Chem* 49: 93-107.
7. Howe, PE. 1921. The determination of proteins in blood—a micro method. *J Biol Chem* 49: 109-113.
8. Wolfson, WQ, C Cohn, E Calvary, and F Ichiba. 1948. A rapid procedure for the estimation of total protein, true albumin, total globulin, alpha globulin, beta globulin and gamma globulin in 10 ml of serum. *Am J Clin Pathol* 18: 723-730.
9. Saifer, A, S Gerstenfeld, and F Vacsler. 1961. Photometric microdetermination of total serum globulins by means of a tryptophan reaction. *Clin Chem* 7: 626-636.
10. Saifer, A and T Marven. 1966. The photometric microdetermination of serum total globulins with a tryptophan reaction: a modified procedure. *Clin Chem* 12: 414-417.
11. Gendler, SM. 1989. Albumin. *In: LA Kaplan and AJ Pesce, eds., Clinical Chemistry: Theory, Analysis, and Correlation.* St. Louis: The C.V. Mosby Company; pp. 1029-1033.
12. Webster, D, AHC Bignell, and EC Attwood. 1974. An assessment of the suitability of bromocresol green for the determination of serum albumin. *Clin Chim Acta* 53: 101-108.
13. Louderback, A, EH Mealey, and NA Taylor. 1968. A new dye-binding technic using bromocresol purple for determination of albumin in serum. *Clin Chem* 14: 793-794. (Abstract)
14. Pinnell, AE and BE Northam. 1978. New automated dye-binding method for serum albumin determination with bromocresol purple. *Clin Chem* 24: 80-86.
15. King, EJ and AR Armstrong. 1934. A convenient method for determining serum and bile phosphatase activity. *Can Med Assoc J* 31: 376-381.
16. Kind, PRN and EJ King. 1954. Estimation of plasma phosphatase by determination of hydrolysed phenol with amino-antipyrine. *J Clin Pathol* 7: 322-326.
17. Ohmori, Y. 1937. Über die Phosphomonoesterase. *Enzymologia* 4: 217-231.
18. Fujita, H. 1939. Über die Mikrobestimmung der Blutphosphatase. *J Biochem, Japan* 30: 69-87.
19. Petitclerc, C, M Delisle, M Martel, C Fecteau, and N Brière. 1975. Mechanism of action of Mg^{2+} and Zn^{2+} on rat placental alkaline phosphatase. I. Studies on the soluble Zn^{2+} and Mg^{2+} alkaline phosphatase. *Can J Biochem* 53: 1089-1100.
20. Tietz, NW, CA Burtis, P Duncan, K Ervin, CJ Petitclerc, AD Rinker, D Shuey, and ER Zygowicz. 1983. A reference method for measurement of alkaline phosphatase activity in human serum. *Clin Chem* 29: 751-761.
21. Bowers, GN, Jr, HU Bergmeyer, M Hørder, and DW Moss. 1979. IFCC methods for the measurement of catalytic concentration of enzymes. Part I. General considerations concerning the determination of the catalytic concentration of an enzyme in the blood serum or plasma of man. *Clin Chim Acta* 98: 163F-174F.
22. McNeely, MDD. 1989. Amylase. *In: LA Kaplan and AJ Pesce, eds., Clinical Chemistry: Theory, Analysis, and Correlation, 2nd ed.* St. Louis: The C.V. Mosby Company; pp. 906-909.
23. Zinterhofer, L, L Wardlaw, P Jatlow, and D Seligson. 1973. Nephelometric determination of pancreatic enzymes. I. Amylase. *Clin Chim Acta* 43: 5-12.
24. Centers for Disease Control. 1975. Alpha-amylase methodology survey I. Atlanta: US Public Health Service; Nov, 1975.
25. Somogyi, M. 1960. Modifications of two methods for the assay of amylase. *Clin Chem* 6: 23-35.
26. Gillard, BK, HC Markman, and SA Feig. 1977. Direct spectrophotometric determination of a-amylase activity in saliva, with *p*-nitrophenyl α -maltoside as substrate. *Clin Chem* 23: 2279-2282.
27. Wallenfels, K, P Földi, H Niermann, H Bender, and K Linder. 1978. The enzymic synthesis, by transglucosylation of a homologous series of glycosidically substituted malto-oligosaccharides, and their use as amylase substrates. *Carbohydrate Res* 61: 359-368.
28. Karmen, A. 1955. A note on the spectrophotometric assay of glutamic-oxalacetic transaminase in human blood serum. *J Clin Invest* 34: 131-133.
29. Bergmeyer, HU, GN Bowers Jr, M Hørder, and DW Moss. 1977. Provisional recommendations on IFCC methods for the measurement of catalytic concentrations of enzymes. Part 2. IFCC method for aspartate aminotransferase. *Clin Chem* 23: 887-899.
30. Ball, EG, JP Revel, and O Cooper. 1956. The quantitative measurement of γ -glutamyl transpeptidase activity. *J Biol Chem* 221: 895-908.

14. Bibliography (continued)

31. Goldbarg, JA, OM Friedman, EP Pineda, EE Smith, R Chatterji, EH Stein, and AM Rutenburg. 1960. The colorimetric determination of γ -glutamyl transpeptidase with a synthetic substrate. *Arch Biochem Biophys* 91: 61-70.
32. Orłowski M and A Meister. 1963. γ -Glutamyl-*p*-nitroanilide: a new convenient substrate for determination and study of L- and D- γ -glutamyltranspeptidase activities. *Biochim Biophys Acta* 73: 679-681.
33. Persijn, JP and W van der Slik. 1976. A new method for the determination of Gamma-Glutamyltransferase in serum. *J Clin Chem Clin Biochem* 14: 421-427.
34. Shaw, LM, JH Stromme, JL London, and L Theodorsen. 1983. IFCC methods for the measurement of catalytic concentration of enzymes. Part 4. IFCC method for Gamma-Glutamyltransferase. *J Clin Chem Clin Biochem* 21: 633-646.
35. Meites, S. 1982. Bilirubin, direct reacting and total, modified Malloy-Evelyn method. *In: WR Faulkner and S Meites, eds., Selected Methods of Clinical Chemistry, vol. 9. Washington, DC: American Association for Clinical Chemistry; pp. 119-124.*
36. Koller, A and LA Kaplan. 1989. Total serum protein. *In: LA Kaplan and AJ Pesce, eds., Clinical Chemistry: Theory, Analysis, and Correlation, 2nd ed. St. Louis: The C.V. Mosby Company; pp. 1057-1060.*
37. Reigler, E. 1914. Eine kolorimetrische Bestimmungsmethode des Eiweisses. *Z Anal Chem* 53: 242-245.
38. Weichselbaum, TE. 1946. An accurate and rapid method for the determination of proteins in small amounts of blood serum and plasma. *Am J Clin Path* 16: 40-49.
39. Dumas, BT, DD Bayse, RJ Carter, T Peters Jr, and R Schaffer. 1981. A candidate reference method for determination of total protein in serum. I. Development and validation. *Clin Chem* 27: 1642-1650.
40. CLSI. 1992. Physician's Office Laboratory Guidelines, 2nd ed; Tentative Guideline. NCCLS document POL1-T2 (ISBN 1-56238-159-8). Villanova, PA: NCCLS; pp. A24-A28, A34.
41. CLSI. 1984. Procedures for the Handling and Processing of Blood Specimens; Tentative Standard. NCCLS document H18-T. Villanova, PA: NCCLS; p. 219.
42. Rehak, NN and BT Chiang. 1988. Storage of whole blood: Effect of temperature on the measured concentration of analytes in serum. *Clin Chem* 34: 2111-2114.
43. Balistreri, WF and R Rej. 1994. Liver function. *In: CA Burtis and ER Ashwood, eds., Tietz Textbook of Clinical Chemistry, 2nd ed. Philadelphia: W.B. Saunders Company; p. 1466.*
44. Jacobs, DS, WR DeMott, PR Finley, RT Horvat, BL Kasten, Jr, and LL Tilzer. 1994. Laboratory Test Handbook, 3rd ed. Hudson, OH: Lexi-Comp Inc.; pp. 127-128.
45. Benet, LZ and RL Williams. 1990. Design and optimization of dosage regimens: pharmacokinetic data. *In: AG Gilman, TW Rall, AS Nies, and P Taylor, eds., Goodman and Gilman's The Pharmacological Basis of Therapeutics, 8th ed. New York: McGraw-Hill, Inc.; pp. 1650-1735.*
46. Moss, DW and AR Henderson. 1994. Enzymes. *In: CA Burtis and ER Ashwood, eds., Tietz Textbook of Clinical Chemistry, 2nd ed. Philadelphia: W.B. Saunders Company; pp. 735-896.*
47. CLSI. 1986. Interference Testing in Clinical Chemistry; Proposed Guideline. NCCLS Publication EP7-P. Villanova, PA: NCCLS; pp. 315-330.
48. Painter, PC, JY Cope, and JL Smith. 1994. Appendix. *In: CA Burtis and ER Ashwood, eds., Tietz Textbook of Clinical Chemistry, 2nd ed. Philadelphia: W.B. Saunders Company; pp. 2161-2217.*
49. CLSI. 1992. Physician's Office Laboratory Guidelines, 2nd ed; Tentative Guideline. NCCLS document POL1-T2 (ISBN 1-56238-159-8). Villanova, PA: NCCLS; pp. A24-A28, A34.
50. CLSI. 1984. Procedures for the Handling and Processing of Blood Specimens; Tentative Standard. NCCLS document H18-T. Villanova, PA: NCCLS; p. 219.
51. Rehak, NN and BT Chiang. 1988. Storage of whole blood: effect of temperature on the measured concentration of analytes in serum. *Clin Chem* 34: 2111-2114.
52. Henry, RJ, DC Cannon, and JW Winkelman. 1974. Clinical Chemistry: Principles and Technics, 2nd ed. New York: Harper and Row; pp. 417-421; 1058-1059
53. Jacobs, DS, WR DeMott, PR Finley, RT Horvat, BL Kasten, Jr, and LL Tilzer. 1994. Laboratory Test Handbook, 3rd ed. Hudson, OH: Lexi-Comp Inc.; pp. 127-128.
54. Benet, LZ and RL Williams. 1990. Design and optimization of dosage regimens: pharmacokinetic data. *In: AG Gilman, TW Rall, AS Nies, and P Taylor, eds., Goodman and Gilman's The Pharmacological Basis of Therapeutics, 8th ed. New York: McGraw-Hill, Inc.; pp. 1650-1735.*
55. Moss, DW and AR Henderson. 1994. Enzymes. *In: CA Burtis and ER Ashwood, eds., Tietz Textbook of Clinical Chemistry, 2nd ed. Philadelphia: W.B. Saunders Company; pp. 735-896.*
56. CLSI. 1986. Interference Testing in Clinical Chemistry; Proposed Guideline. NCCLS Publication EP7-P. Villanova, PA: NCCLS; pp. 315-330.
57. Painter, PC, JY Cope, and JL Smith. 1994. Appendix. *In: CA Burtis and ER Ashwood, eds., Tietz Textbook of Clinical Chemistry, 2nd ed. Philadelphia: W.B. Saunders Company; pp. 2161-2217.*
58. Young, DS. 1990. Effects of drugs on clinical laboratory tests, 3rd ed. Washington, DC: AACC Press.

14. Bibliography (continued)

59. Young, DS. 1991. Effects of drugs on clinical laboratory tests. 1991 supplement to the third edition. Washington, DC:
60. CLSI. 1992. Evaluation of Precision Performance of Clinical Chemistry Devices, 2nd ed.; Tentative Guideline. NCCLS document EP5-T2. Villanova, PA: NCCLS.